SCIOGRAPHIA,
OR
THE ART
OF
SHADOVVES.

Plainly demonstrating, out of the Sphere, how to project both great and small circles, upon any Plane whatsoever: with a new Conceit of reflecting the Sunne beames upon a Diall, contrived on a *Plane*, which the direct beames can never shine upon.

TOGETHER

With the manner of cutting, the five Regular Platonicall bodies; and two other, the one of 12, the other of 30 Rhombes, never discovered heretofore; also the finding of their *Declinations, and Reclinations, and adorning them with variety of Dials.*

All performed, by the Doctrine of Triangles; and for ease, and delight sake by helpe of the late invented, and worthily admired Numbers, called by the first Inventor *Logarithmes*.

By I. W. *Esquire*.

LONDON,
Printed by THOMAS HARPER, and are to be sold in *Pauls* Church-yard, at the signe of the Bell, 1635.

- p.26

HENRY GELLIBRAND

TO THE LOVER OF the *Mathematiques*:

SHADOWES are defined by our * Masters of the *Optiques*, to be but *Imminutions of Light* caused by the *Interceptions of Opacous bodies*. VVhose subtile entitie, hath mooved some *great* * *Geometers*, to assimilate them unto a *Superficies*, and tearme them Επιφανειαι, that is to say, *Apparences*. Neverthelesse it hath pleased the *Fountaine of all Wisdome*, to bound even these *Shadowes* with *Precepts*, and range them within the *societie of Arts*. Neither stands this *Art of shadowes* in any *darke or inferiour Place*; for by them

* *Vitello. Risnerus.*

* *Apollonius. P. Ramus.*

are we led on to many *rare and sublime speculations*. It is from *Shadowes* wee argue the cause of *Eclipses*, their *Quantitie and Qualitie*; The *Magnitudes* of the *Luminaries* and their *Altitudes*; From them we obtaine the *Longitudes and Latitudes* of Places; distinguish the *Zones*, *Climes*, *and Paralels*; They first taught us the *Sphericall Figure* of the *Earth*, its *Magnitude*, *and Disproportion* to the vast Universe; To these are our best *Painters* indebted for the Life and Grace of their choicest *Pieces*; And to these (if we may beleeve *Ptolemy*) are the mutable conditions of *Men*, *Kingdomes*, *and Commonwealths* imputed. In a word, it is this *Art of Shadowes* which rectifieth our *Account of Time*, not after that Rustique hungry way of a gratefull decupled shadow, (the time of an approching supper) but by a certaine and demonstrative distinction thereof. For though the Ancients, who spun long threads of life, had scarce any further respect to the parts of the day, than the *Morning*, *Noone and Evening*;

vening; Yet as the ſtocke of life after ſome few *Ages* began to ſpend, ſo they likewiſe to attend a more ſerious & prudent expence thereof, and to diſcriminate the day into ſmaller particles. Now becauſe among the heavenly bodies, that bright Lampe of the VVorld, is the *Principall Meaſurer of Time*, and the *Eye* alone not able by thoſe variable altitudes, to diſtinguiſh its *Diurnall archs* into ſmaller portions, therefore have ſome deepe and witty *Artiſts* taught the Sunne to trace out his way upon the Earth, and by the ſhadow of an *Axis* to marke out thoſe leſſe parts of the day unto us. The first *Gnomicall Organ*, which ſtands upon Record, is the *Diall* of King* *Ahaz* (wherby the Almighty was pleaſed to expreſſe a miracle for the recovery of King *Hezekiah*, and moved the *Babylonian Ambaſſadours* to inquire of the *wonder* that was done in the Land) which whether it were a *Convex or Concave Hemiſphere*, (as moſt genuine and naturall, and afterwards familiar among the *Chaldeans*) is yet left

* 2. *King.* 20. 11.

Eſay 38. 8.

2. *Chron.* 32. 31.

undecided. Yet ſome there are, who crowne *Anaximenes the Lacedemonian* therwith, as firſt giving breath to the *Scioteriques*. It crept into *Rome* later, as more addicted to the Diſcipline of the Field, then of the Heavens, contenting themſelves only with the *Riſing and Setting of the Sunne* digeſted into the twelve Tables; *Accenſus* the Conſull afterward determining the *Noon-tide*, and that only in ſereno dayes, ſoone after the *Punique* warre. And no further light had they till the *Conſul M. Val. Meſſala*, beautified a Colume with a Diall neere the *Roſtra*, ſaith *Varro*. The *excavated Hemiſphere* is attributed to *Beroſus* the *Chaldæan*, after the taking of *Catana in Sicilie*. Others voice it on that witty Samian *Ariſtarchus*, (to whom *Copernicus* is indebted for his *Heroicke Hypotheſis of the Earths Motion*) as firſt ſhadowing out the houre lines on a Plane. Yet ſure *the Scaphe or Concave Hemiſphere* was in uſe before him; for *Eratoſthenes* is well knowne to have determined thereby, ſome *Celeſtiall and Terreſtriall*,

restriall distances. But what the *Superficies* was, or who the prime Inventer in those Cloudy Times, is not much materiall. This we know, that for the complement of this Art two of the most Divine must descend from Heaven to consult thereon; the *One* conferring *lines*, that other the *Substile motion of the Sunne.* The *Surveyour* may search out *Altitudes*, *Longitudes, and Latitudes*; The *Military Architect* fabricate his *Fort*; The *Enginer* plant his *Canon*, *Convey* his *Myne*, by the only helpe of *three right Lines*; But the compleat *Shadowist* cannot here rest without further helpe from above. For besides his skill in the *Spheriques*, together with the Lawes of that greater Luminaries motion, he must be absolute in all its *Circular Affections*, as *Declinations*, *Right and Oblique Ascentions*, *Altitudes*, *Amplitudes*, *Azimuthes*, *Culminations*, *Arches Diurnall*, *Ascendent*, *Descendent*, *&c.* Truly the light is sweet, and a pleasant thing it is for the Eyes to behold the Sunne, (as the VVise man saith) how much more when ac- *Eccles.* 11.7

com-

companied with such varietie of dispartitions. Neither resteth it here only, though affording a seat of sufficient contentment, but proceeds to a further benefit in humane affaires. What more invaluable than *Time*? we having nought to boast of but only its possession, and that more momentany than the fleeting Shadow it selfe; the *Future* houre is no more mine than the *Precedent*, only *Hope* (a weake staffe whereon we too much rest) makes me Lord of it, & yet out of which every small casualtie can expell me. Hee then is the *good Steward* that well improves it, and the better in being jogged on by a frequent Remembrancer, which this mute Monitor faithfully performes.

Here have we then by this *learned Authour*, the art of numbring Time by Shadowes, after the most *Methodicall, Compendious and Perspicuous* manner *compleatly and demonstratively* delivered for all *Planes*, both by *Lines and Numbers.* The worth of the worke will be best valued by those, who after much wandring

have

have at length sate downe wearied, with the obscure and toylsome *Labyrinths* of others. There can be found no neerer path then that which leads in the shortest extension; this I suppose to sute best with Pilgrims, who have long wayes and short lives; It will become those that enter the same, to reverence the *Finger directive*, and blesse *God, the Father of Lights*, from whom every good gift descends.

London, Gresham Colledge,
June 6. 1635.

THE AVTHOR TO THE READER.

This tract of Dyalling was written for mine owne private delight and exercise, above thirteene yeeres since, as divers of my friends know: wherein I have beene the more curious, to handle every kind of Plane; not with any thought, or purpose, ever to print the same, but to keepe it by me, for satisfaction to my selfe, and friends whensoever there should be cause to use it. Yet shortly after the Worke was finished, occasion to make use of it, drew on occasion for my friends to take notice thereof: amongst the rest, my two late worthy friends, Master Henry Briggs, *(iustly*

stiled

ſtiled by a Reverend Divine our English Archimedes) *and Maſter* Edmund Gunter, Aſtronomie Lecturer of Greſham Colledge, *deſired to peruſe it; and finding that the Arithmeticall part was performed by Logarithmes of both kinds, and therefore might ſerve inſtead of uſes for the Chiliads and Canon, compiled by them; did earneſtly ſollicite mee to print the ſame: but they both dying, this motion of theirs died with them.*

Of late it hath beene againe revived, by the requeſt of other Friends; but eſpecially by the encouragement of my much reſpected, and learned Friend Maſter Henry Gellibrand, *who hath annexed his approbation of that, which in my owne* opinion *I never thought worthy of ſo much eſteeme. I have therefore at length (yeelding to the importunitie of Friends) conſented to let it paſſe to the publike view. If any benefit grow from it, let him have the honour, that is the Authour of all good gifts, and let my Friends ſhare in the thankes, that have in a manner extorted it out of my hands.*

I have prefixed an Index *of the principall matters, contained in the whole* Booke, *diſtinguiſhed into Chapters, with the faults eſcaped therein; to the end, that*

bee

hee that will not take the paines to read all over, may fix upon those Chapters that will serve his turne, and correct the faults of them before he begin to read. Many more no doubt have escaped, the rather because I could not attend the Presse my selfe, which you may mend as you meet with them, and beare with the common frailty of all Mankind.

J. W.

AN INDEX OF THE PRINCIPALL MATTERS OF THIS Booke, with the faults escaped therein.

CHAP. I.

Faults escaped in this Chapter.

2 lin. 35. 34630. for 34730. the sine of 10 d. doubled.

CHAP. II.

Faults escaped in this Chapter.

8 C omitted in the third Diagram.
10 lin.33. 90 d. for 60 d.
11 lin.20 The line left out betweene the Sun and differs of the Logarithmes.
28 the for these.
16 lin.25 (the sine of) superfluous, to be stroke out.
17 lin. 7 & 28 Arith. complement twice omitted.
19 lin. 2.3.4. the 3 Angles A B C, should have beene set a part, and all summed up together.

Chap. III.

38.

Faults escaped in this Chapter.

21.lin.28. (two) for second.
22.lin.30. The line betweene the 2 last Logarithmes left out.
31.lin.20. Sides for side.
32.lin.20. ♋ must be stroke out as superfluous.
34 In the first Diagram, O for P.
43.lin. 2. given, for sought.
Lin. 3. sought for given.
44. In the 2 Diagram, P in the place of S, & S in the place of P.
47.lin.11. P Z S, for Z P S.
51.lin. 5. R Z S for R Z P.

Chap. IV.

Faults

Faults escaped in this Chapter.

Pag.		
58	lin. 36	be for by, and with for which.
60	lin. 2	Poles for Pole.
62	lin. 16	90 d. 46′. for 70 d. 46′.
64	lin. 6	Cordinall, for Cardinall.
65	lin. 21	Sines for lines.

Chap. V.

Faults escaped in this Chapter.

65	lin. 26	steight for streight.
69	lin. 23	20 for ZO.
71	lin. 27	Substice for substile.
73	lin. 12	vertix for vertex.

Chap. VI.

Faults escaped in this Chapter.

Chap. VII.

Faults escaped in this Chapter.

Chap. VIII.

Faults escaped in this Chapter.

92 lin. 26 Plane for plaine.
94 lin. 12 the first 39 d. 54′. superfluous to be stroke out.
lin. 16 returning for returneth.
lin. 17 on for off.
lin. 32 but for out.

Chap. IX.

Faults escaped in this Chapter.

98 lin. 28 Arithmeticall complement left out.
31 $\underline{0\ 9}$ for $\underline{0\ 77}$.
101 lin. 6 each : for the East.

The Contents.

Chap. X.

The first part.

Faults escaped in this Chapter.

105 lin. 23 R Z for Q Z.

106 lin. 2 lines for line.

21 (the) left out.

108 lin. 10 *and* 11 *South part, should be West part, and North part, East part* [o]*f the Plane.*

25 A x for H x.

Chap.

The Contents.

CHAP. X.

The second part.

The Contents.

Faults escaped in this Chapter.

114 lin. 3 the word (degree) is superfluous, and must be stroke out.

11 fift case, for the ninth case.

115 lin. 31 Houres distance, for houre distances.

116 lin. 28 (for 3 of clocke) superfluous, and must be stroke out.

118 lin. 22 appeares for appeare.

Chap. XI.

128

Faults escaped in this Chapter.

127 lin. 8 the for that.
129 lin. 11 $\frac{68}{100}$ parts for $\frac{86}{100}$.
22 Arith. complement superfluous to be stroke out.

Chap. XII.

Faults escaped in this Chapter.

133 lin. 8 Z 3 for Z O.
134 lin. 31 two for second.
135 lin. 7 two againe for second.
136 lin. 26 P R 8 for R P 8.

Chap. XIII.

Faults escaped in this Chapter.

147	lin.	2	South reclining 23 d. for 25 d.
150	lin.	25	being for bring.
153	lin.	1	(is 64 d. 10′.) left out.
156			in the Scheme 65 d. 31′. should be 65 d. 40′.
157	lin.	10	differences left out.

Chap. XIV.

Faults escaped in this Chapter.

160 lin. 8 sixteene halfe houres; for sixteene houres and a halfe.
162 lin. 1 The *data*, and *quæsita* of this Diall, should have beene placed before the Arith. calculation.
34 The 34 Chapter should be the 35.
167 lin. 4 The 34 Chapter againe for the 35.

Chap. XV.

Faults escaped in this Chapter.

171	lin.	3	ND for NP.
174	lin.	9	Houres distances for houre.

Chap. XVI.

Faults escaped in this Chapter.

176	lin.	7	Pole for Plane.
178	lin.	26	is for to.
		29	triangle for triangles.
179	lin.	5	The unitie in the first place should be cancelled, and the line betweene the first and second Logarithmes left out.
181	lin.	23. 26	product for produce twice.
183	lin:	7	directed for erected.

Chap. XVII.

Faults escaped in this Chapter.

187 lin. 15 fift case for fifteenth.

189 lin. 15 and 18. Logarithmeticall for Logarithmicall.

192 lin. 8 Diall for a Diall.

Chap. XVIII.

Faults escaped in this Chapter.

199 lin. 5 and 6, Logarithmeticall for Logarithmicall.
13 R P S for R P 5.
24 widest for wideth.

Chap. XIX.

Faults escaped in this Chapter.

205 lin. 2 Complement of the Tangent left out.
207 lin. 15 Logarithmeticall for Logarithmicall.

Chap. XX.

Faults escaped in this Chapter.

209 lin. 21 34 Chapter for 35.
214 lin. 23.27.29. Logarithmeticall for Logarithmicall three times.
216 lin. 21 (the) left out.
217 lin. 5 (done) left out.

Chap. XXI.

Faults escaped in this Chapter.

219 lin. 8 recliner for incliner.

Chap. XXII.

Faults escaped in this Chapter.

222 lin. 10 incliner for decliner.
11 deducted for deduced.
224 lin. 20 recliners for recliner.
225 lin. 10 28 d. 38′. for 38 d. 28′.
226 lin. 16 (the) omitted.
227 lin. 3 South declining East 60 d. inclining 16 d. should have stood under the Scheme.

Chap. XXIII.

Faults escaped in this Chapter.

232	lin.	19	whereon: for whereout.
233	lin.	1	angle for angles.
238	lin.	13	whereon for whereout, and (the) omitted.
239	lin.	1	(of) is superfluous.
243	lin.	18	whereon for whereout.
245	lin.	13	widest for width.
		16	angled for the angle d.
		25	d for e.
248	lin.	11	rule for rules.

Chap. XXIV.

Faults escaped in this Chapter.

250 lin. 18 a e h for a e h I.

251 In the paralellipiped a d h should be a n h.

lin. 21 decline for recline.

252 lin. 7 S for P.

255 lin. 5 widest for width.

257 lin. 10 from the 10 line to the 17, a little f mistaken for a great F nine times.

258 lin. 13 a little f for a great F.

260 lin. 21 56 d. 16'. 57''. for 58 d. 16'. 57''.

261 lin. 22 68. 16. 57. for 58. 16. 57.

Chap. XXV.

Faults escaped in this Chapter.

267 lin. 4 (the) superfluous.
268 lin. 4 widest for width.

Chap. XXVI.

Faults escaped in this Chapter.

269 lin. 18 S. for l. and 0407. for 0407.
22 widest for width.
33 A little f twice for a great F, and a little e, for a great E.
270 lin. 5 A great B for a little b.

Chap. XXVII.

Faults escaped in this Chapter.

271 lin. 20 or for of.

272 lin. 10 &.23 widest twice for width.

277 lin. 25 Signes for Sines.

27 (of G C H, B C H, K C H, and L C H, to the lines H G, H B, H I C, and H L, the distances of those paralels from the Center) all left out in printing.

28 *Logar.* superfluous, and must be stroke out.

278 lin. 2 widest for width.

18 0098.61 *for* 0098.51.

281 lin. 1 West for and.

19 widest for width.

285 lin. 15 *Characteristica* for *characteristicall.*

286 lin. 10 widest for width.

289 lin. 8 widest for width.

290 lin. 11 *Cosine* left out.

CHAP.

Chap. XXVIII.

Chap. XXIX.

Faults escaped in this Chapter.

295 lin. 12 22*d. for* 225*d.*

Chap. XXX.

The Contents.

Chap. XXXI.

Faults escaped in this Chapter.

300 lin. 4 Azimuth for Azimuths.
10 widest for width.
24 60p. (p) omitted.
301 lin. 15 widest for width.
302 lin. 25 widests for widths.

Chap. XXXII.

308

Faults escaped in this Chapter.

303 lin. 30 (and) is left out.
304 lin. 28 FG is left out.
307 lin. 22 widest for width.
309 lin. 15 widest for width.
36 (the) is left out.
312 lin. 11 The characteriske of 1 for 0.
14 widest for width.

Chap. XXXIII.

Faults escaped in this Chapter.

313	lin.	24	Pole for Poles, and omitted for united.
314	lin.	24	28 d. 38′. for 38 d. 28′.
		32	S R I for S R the I superfluous.
317	lin.	11	38 d. 28′. for 38 d. 20′.
318	lin.	7	signe + more for the signe — lesse.
380	lin.	13	Logarithmeticall for Logarithmicall.
384	lin.	16	(the) omitted.
		32	Logarithmeticall for Logarithmicall.
385	lin.	15.29	Logarithmeticall for Logarithmicall twice.

Chap. XXXIV.

Faults escaped in this Chapter.

386	lin.	4	*Scoubergius* for *Scoubergerus.*
387	lin.	3	C D B for G D B.

Chap. XXXV.

Faults escaped in this Chapter.

392 lin. 19 (*Case*) is superfluous, to be stroke out.
395 lin. 28 P D V for P D R.
33 and for or.
398 lin. 12 *pag.* 138 should be 148.
399 lin. 11 part for plane.
403 lin. 21 length for heigth.
410 lin. 20 paral for paralell.
30 P for Pole.
35 by the case should be by the sixt case.

Chap. XXXVI.

The Contents.

Faults escaped in this Chapter.

415 lin. 7 (and) superfluous,

418 lin. 21 (from) omitted.

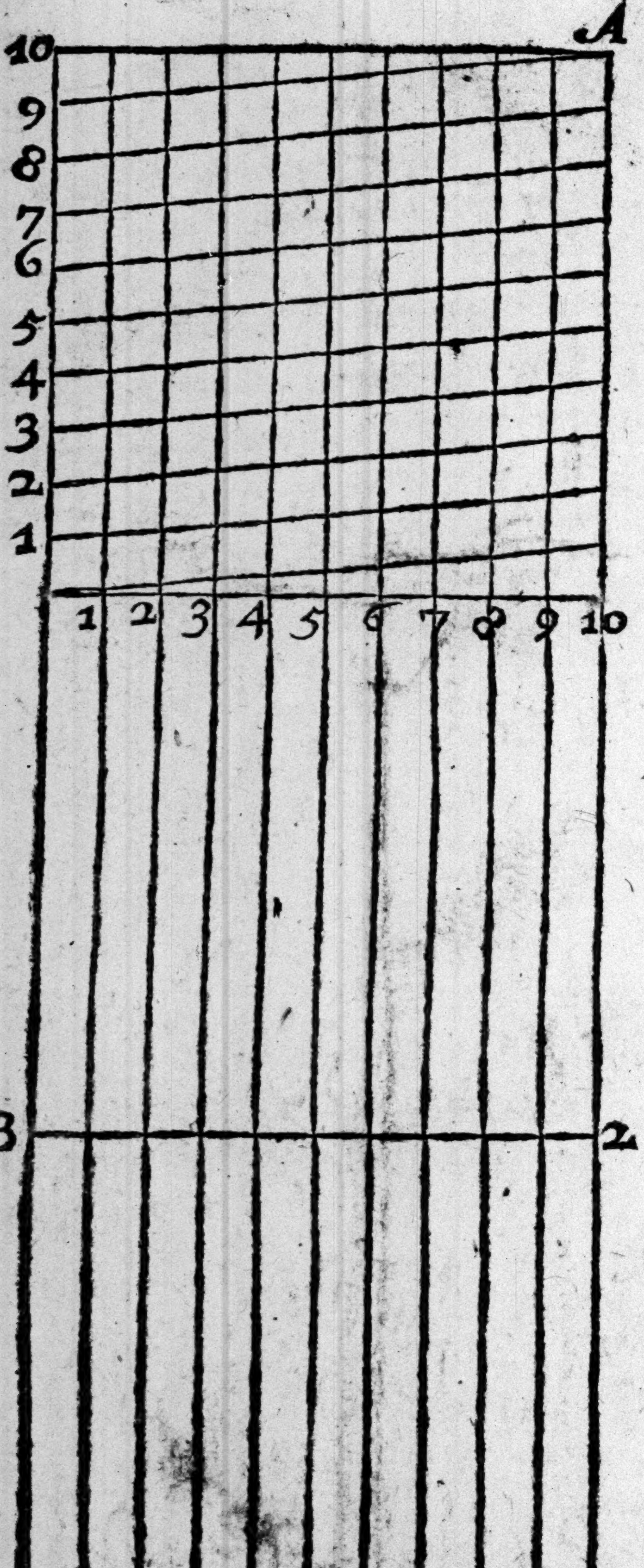
Sunsrise		*Suns set*		*Length of day.*		*Length of night.*		*Breake of day.*		*Twilight*	
H	'	H.	'	H.	'	H	'	H.	'	H	'
4	18	7	42	15	24	8	36	1	8	10	52
4	11	7	49	15	38	8	22	0	37	11	23
4	8	7	52	15	44	8	16	0	11	11	49
4	5	7	55	15	50	8	10	from the twelfth of May.		Continuall day to the twelfth of Iuly.	
3	59	8	1	16	2	7	58				
3	54	8	6	16	12	7	48				
3	51	8	9	16	18	7	42	0	0		
3	48	8	12	16	24	7	36	0	0	0	0
3	47	8	13	16	26	7	34	0	0	0	0
3	47	8	13	16	26	7	34	0	0	0	0
3	49	8	11	16	22	7	38	0	0	0	0
3	52	8	8	16	16	7	44	0	0	0	0
3	55	8	5	16	10	7	50	0	0	0	0
4	0	8	0	16	0	8	0	0	0	0	0
4	6	7	54	15	48	8	12	0	0	0	0
4	8	7	52	15	44	8	16	0	10	11	50
4	12	7	48	15	36	8	24	0	44	11	16
4	19	7	41	15	22	8	38	1	13	10	47
4	27	7	33	15	6	8	54	1	35	10	25
4	35	7	25	14	50	9	10	1	54	10	5
4	46	7	14	14	28	9	32	2	15	9	45
4	55	7	5	14	10	9	50	2	31	9	29
5	4	6	56	13	52	10	8	2	46	9	14
5	13	6	47	13	34	10	26	3	0	9	0
5	23	6	37	13	14	10	46	3	14	8	46
5	32	6	28	12	56	11	4	3	28	8	32

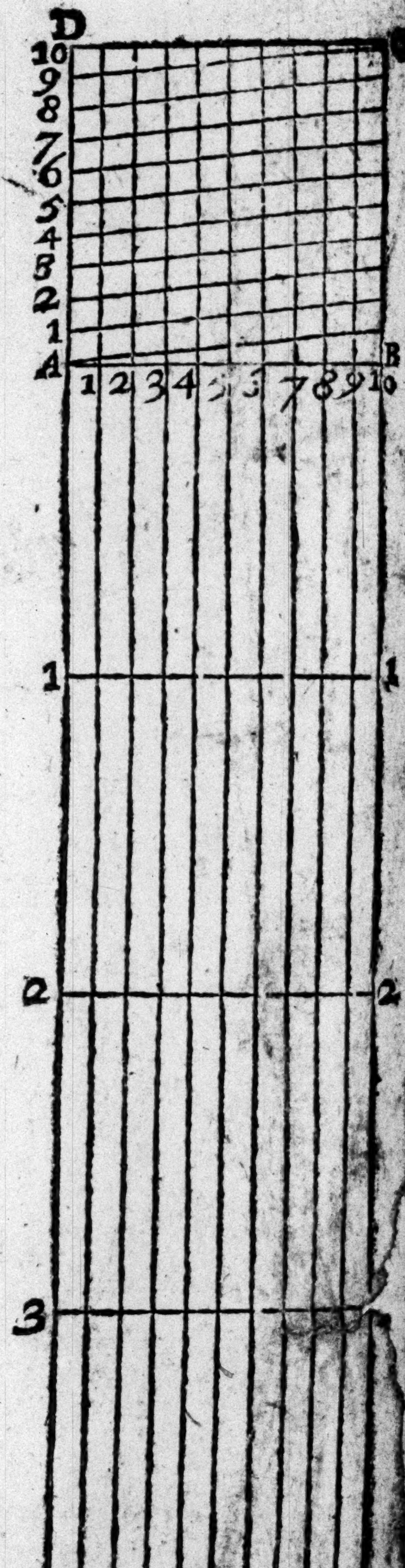
Note that Astronomers accompt it not night, till the Sunne be 18 d. under the Horizon: and therefore we may (according to that acception) conclude it to be continuall day, from the 12 of May to the 12 of July, in all which time the Sunne descendeth not so low under the Horizon.

		The Sunnes place, 1623.				Decli- nation.		Com- plement		Differ: ascenti:		½ Diurnall arches.	
			d	♍	'	d	'	d	'	d	'	d	'
Septem:	5		22	2	22	3	10	86	50	3	58	93	58
	10		26	56	6	1	13	88	47	1	31	91	31
	15	♎	1	50	45	0	44	89	16	0	55	89	5
	20		6	46	18	2	42	87	18	3	24	86	35
	25		11	42	45	4	39	85	21	5	53	84	7
	30		16	40	7	6	34	83	26	8	20	81	40
October.	5		21	38	25	8	28	81	32	10	48	79	12
	10		26	37	34	10	18	79	42	13	13	76	47
	15	♏	1	37	37	12	5	77	55	15	38	74	22
	20		6	38	30	13	47	76	13	17	59	72	1
	25		11	40	14	15	23	74	37	20	16	69	44
	30		16	42	43	16	53	73	7	22	29	67	31
Novem:	5		22	46.	38	18	32	71	28	24	58	65	2
	10		27	50.	36	19	45	70	15	26	52	63	8
	15	♐	2	55.	11	20	49	69	11	28	35	61	25
	20		8	0.	17	21	43	68	17	30	5	59	55
	25		13	5.	50	22	27	67	33	31	20	58	40
	30		18	11.	46	23	0	67	0	32	18	57	42
Decemb.	5		23	17	56	23	21	66	39	32	55	57	5
	10		28	24	23	23	31	56	29	33	13	56	47
	15	♑	3	30	57	23	29	66	31	33	9	56	51
	20		8	37	31	23	15	66	45	32	44	57	16
	25		13	44	4	22	49	67	11	31	58	58	2
	30		18	50	26	22	12	67	48	30	54	59	6

		Sun rise		Sun set.		Length of day.		Length of night.		Breake of day.		Twilight	
		H.	'	H.	'	H.	'	H.	'	H.	'	H.	'
Septem:	5	5	44	6	16	12	32	11	28	3	42	8	18
	10	5	54	6	6	12	12	11	48	3	54	8	6
	15	6	4	5	56	11	52	12	8	4	6	7	54
	20	6	14	5	46	11	32	12	28	4	17	7	43
	25	6	24	5	36	11	12	12	48	4	27	7	33
	30	6	33	5	27	10	54	13	6	4	37	7	23
October.	5	6	43	5	17	10	34	13	26	4	47	7	13
	10	6	53	5	7	10	14	13	46	4	56	7	4
	15	7	3	4	57	9	54	14	6	5	5	6	55
	20	7	12	4	48	9	36	14	24	5	13	6	47
	25	7	21	4	39	9	18	14	42	5	21	6	39
	30	7	30	4	30	9	0	15	0	5	29	6	31
Novem:	5	7	40	4	20	8	40	15	20	5	37	6	23
	10	7	47	4	13	8	26	15	34	5	42	6	18
	15	7	54	4	6	8	12	15	48	5	47	6	13
	20	8	0	4	0	8	0	16	0	5	52	6	8
	25	8	05	3	55	7	50	16	8	5	56	6	4
	30	8	9	3	51	7	42	16	18	5	59	6	1
Decemb.	5	8	12	3	48	7	36	16	24	6	0	6	0
	10	8	13	3	47	7	34	16	26	6	1	5	59
	15	8	13	3	47	7	34	16	26	6	1	5	59
	20	8	11	3	49	7	38	16	22	6	0	6	0
	25	8	8	3	52	7	44	16	16	5	58	6	2
	30	8	4	3	56	7	52	16	8	5	55	6	5

FINIS.





Place this folio 1.

The Art of SHADOWES, Commonly called DIALLING;

Plainely shewing out of the Sphere, the true ground and reason of making all kinde of DIALS that any Plane is capable of.

Chap. I.

How to divide divers lines, and make a chord to any proportion required.

BEcause there is continuall use, both of scales and chordes, in drawing the Schemes and Dyals following, it will be necessary first to shew the making of them, that such as cannot have the benefit of the skilfull Artificers labour, may by their owne paines supply that defect.

Draw therefore the straight lines, E 2, & H 3, of what length you will, let E F, & H G, F I, & G I, or as many more parts as are needfull, be equall to any Radius given, as these are to H O, & L O, of the Dyall in the 11. chapter, (to which they may be particularly applyed) subdivide EF, & H G, into tenne equall parts, and each part againe into halfes, or rather into tenne parts more, if the lines E F, & H G, will permit, so may you of them (as you doe of a sector) take any part of a streight line, or naturall Tangent desired. And note, that wheresoever I speake of using the Sector, a line thus divided may serve the turne, seeing the line of equall parts thereupon is onely understood in this Treatise, and the opening of the Sector to the length of any Radius, is alwaies intended to be betweene 100. and 100. of those equall parts.

But if you make a paralellogram like unto D 4, G 4, (whos bredth and length is arbitrary, and may be proportioned to any Radius given) and divide the bredth therof into ten parts, and the first part (equall to the Radius) by diagonall lines into 10 parts, as in the example of A B C D, which is an inch divided each way into ten parts, the work will bee much more exact in imitation thereof, the figure adjoyning A 10, B 2, is fitted to the Radius of the fundamentall schem, by help whereof the places or points of P, B, A, K, and O, proper to the circles passing thorow them, as also the centers of them, and of the houre circles, 8, 7, L, 5, 4, 3, &c which are given in naturall Tangents may aptly be found and inscribed.

The naturall Sines, Tangents, and Secants, are in every mans hands; where they are wanting, they may be easily supplied out of the artificiall numbers in the end of the book: for if you seek the Logarithme of any degree and minute (omitting the characterisk) in the Chiliades, the absolute number answerable thereto is the naturall Sine, Tangent, or Secant of the degree and minute desired.

d. '	Log.Sin.	Log.Tang.	Log.Sec.
10.16	9250.9803.	9257.9901.	10007.0098.

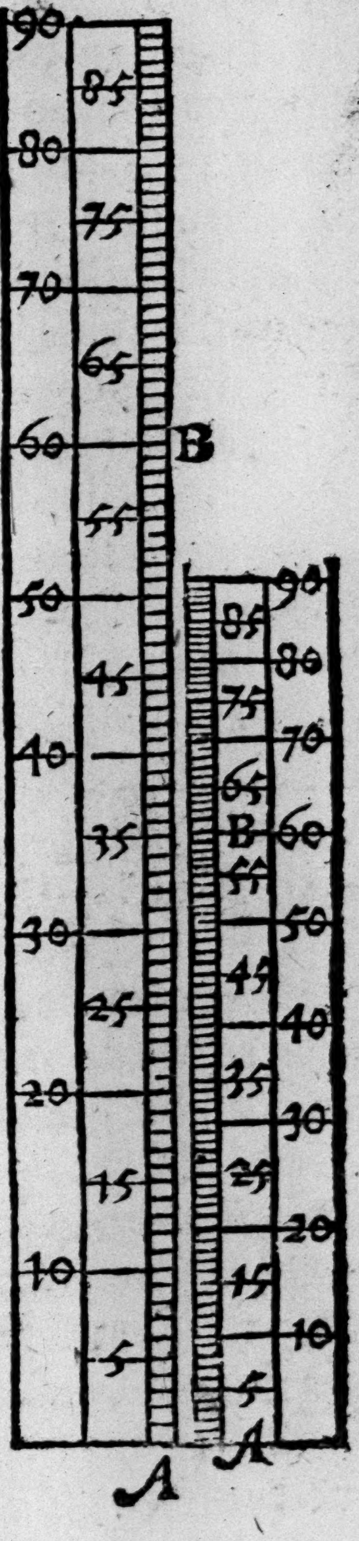
Nat.Si. 17823. nat.Tan. 18113 nat.Sec. 101627.

Only remember to take the Logar. of the complement of the degree and minute desired for the Secant, because the Logarithmes of the Secants in this table, are turned into the Arith. complem. of the Sines, and the characterisk left out, without my privity, which would have served this purpose much better without any conversion.

To make therfore the line of chords, prepare a table, therin set down first the degrees & parts, if you will, from 1 d. proceeding to 90 d, unto each degree joyn the chord proper to it, which is the naturall Sine of halfe the arch doubled, by the tenth of the fift of *Finkius*, for if you double the naturall Sines of 5.10.20.30 d. &c you shall produce the chords of 10.20.30.40 d. So of 17365 the Sine of 10 d. doubled, commeth 34730 the chord of 20 d. and of 25881 the Sine of 15 d. doubled, commeth 51764 the chord of 30 d. and so of the rest: This done, proportion the Ra-

dius

Gra.	Chor.	Gra.	Chor.	Gra.	Chor.
1	017	31	534	61	1015
2	035	32	551	62	1030
3	052	33	568	63	1045
4	070	34	585	64	1060
5	087	35	601	65	1074
6	105	36	618	66	1089
7	122	37	635	67	1104
8	139	38	651	68	1118
9	157	39	668	69	1132
10	175	40	684	70	1147
11	192	41	700	71	1161
12	209	42	717	72	1176
13	226	43	733	73	1190
14	244	44	749	74	1204
15	261	45	765	75	1217
16	278	46	781	76	1231
17	296	47	797	77	1245
18	313	48	813	78	1259
19	330	49	830	79	1273
20	347	50	845	80	1286
21	364	51	861	81	1299
22	382	52	875	82	1312
23	398	53	892	83	1325
24	416	54	908	84	1338
25	432	55	923	85	1351
26	450	56	939	86	1364
27	466	57	954	87	1377
28	484	58	970	88	1389
29	501	59	984	89	1402
30	518	60	1000	90	1414



dius of the fundamentall scheme Z S to what length you will, and let A B 60 d. of the lesser chord be equall thereto, supposed to be divided into 100. 1000. or 10000. parts out of the parallellograme A 10, B 20 fitted to that Radius; or having a Sector, open it in the line of equall parts to the wideth of the Radius, and take of either of them 87. that is so many hundreth parts of one tenth for 5 d. & 174 that is one tenth & 74. hundred parts for 10 d. & 261, that is 2 tenths & 61 hundred parts for 15 d. and so of the rest: all which you must transferre into the line A B from A upwards unto 90 d. Having by these meanes first prickt downe every 5 & 10 degree, returne againe to the Table, and by the same meanes pricke downe every intermediate degree also: notwithstanding if you like not to be so curious, you may safely subdivide every five degrees of the smaller chorde into equall parts, seeing the difference of each degree increasing in so small a forme is insensible. From this ground there followeth an easie way of making one particular line of chordes, if you like to be confined to the scantling. The Sector hath for the most part a line of Sines thereupon, let 60 d. of the chorde, be equall to 30 d. of the Sines, taken from the center. In like proportion 5. 10. 15. 20. 25. 40. & 45 d. of the Sines, will be equall to 10. 20. 30. 40. 50. 60. 70. 80. & 90 d. of the chorde, without opening the Sector at all: wherefore if you take the severall degrees and parts of the line of Sines, and transferre them into the line of chords, and write the double number of the Sine upon the chord, you have done what you desired: in like manner, if you make a circle whose Radius shall bee equall to 30 d. of the Sines taken from the center, you may thereupon (by taking ½ the arch of the line of Sines from the center) set any degree of the quadrant as of a chord prepared for the purpose, because the Sine of 30 is to the Radius or chord of 60 d. as the Sine of every halfe arch is to the chord of the same; By this rule you may likewise supply the want of any chord with the help of the scale of inches only: so in the fourth diagram of the sixt Chapter, because the semidiameter N C, or C S, of the circular Plane N I C S agreeth with neither chord, I finde the length thereof by the scale of inches, to be 137, that is 1 inch and 37 hundred parts, wherfore as the Sine of 30 d. is to

the

the ſemidiameter N C 137 ſo is the Sine of 36 d. 58′, halfe the arch S K, to the chord of S K 165, that is 1 inch and 65 hundred parts, next hand, and ſo of the reſt.

The inſtruments being thus prepared for the Mechanicall part, it followeth next that we lay the foundation for the Arithmeticall work, which conſiſteth of Triangles both right lined and ſphericall: firſt therefore of right lined Triangles.

CHAP. II.

Of the ſeverall Caſes and varieties of right lined Triangles, with diverſe cautions to be obſerved in the practice of them.

THE angles and ſides of all ſphericall Triangles are meaſured by the degrees and parts of a great circle, therefore the Canon alone is ſufficient for them: but the ſides of right lined Triangles are meaſured by the equall parts of ſome known ſcale, and therefore the Chiliades in the ſolution of them muſt be joyned with the Canon; notwithſtanding if you ſeek the naturall Sines and Tangents anſwerable to the angles given amongſt the abſolute numbers, and take the Logarithmes of them, you may reſolve the queſtion by the Chilliades alone, in the uſe whereof theſe cautions may bee obſerved.

1 Whereas the Logarithmes in the Chilliades are extended to 11 places, and in the Canon but to 8, in the uſe of both together you may not exceed the like number of places in each, but more or fewer at your pleaſure.

2 The Logarithmes of all numbers greater than an unity, are abundant, marked thus +; of all leſſe than an unity, are defective, marked thus −, and are therefore ſaid to bee leſſe than nothing, becauſe the Logarithme of the unity is made nothing.

3 If the Logarithmes of the three proportionals given, bee all abundants, the firſt ſubtracted out of the ſumme of the ſecond and the third, gives the fourth: if the firſt of the three be defective, the ſumme of all the three is the fourth: if either of the

the middle termes be defective, the ſumme of the firſt and that defective ſubtracted out of the third, gives the fourth : If all three bee abundant, and yet produce a defective in the fourth place, the arithmeticall complement of the characterisk proper to that fourth, ſhall give the true fraction deſired, obſerving the ſame rules in defectives that are required in abundants.

4 If the three proportionals given bee all abſolute numbers abundant, and the Radius none of them, you may avoyd ſubtraction, by changing the Logarithme of the firſt proportionall into its arithmeticall complement; as for 2507.8559, the Logarithme of 322, take 7492.1441, and adde all together: but if the Logarithme of the Radius be one of the middle termes, ſubtraction will be as eaſie as addition.

5 If you like not to work with numbers of divers natures together, you may make all abundants, by ſuppoſing the fractions to bee whole numbers, and changing the characterisk accordingly; ſo have you in the fourth caſe of obliques, the three ſides,

A B- 923	all abundant,	A B-0923	parts of an inch defect.
A C-2033	whereas they	A C-2033	2 inches and parts a-
B C-2546	are indeed	B C-2546	bundant.

6 Many queſtions proper to the Chilliads are reſolved without regard to the characterisk, ſo that wee may finde the abſolute number anſwerable to the Logarithme of the fourth proportionall, by changing the characterisk at pleaſure, in ſeverall Chilliads, every one neerer the truth than other; for if you ſeek the Logarithme of the ſide A C in the Triangle A C B of the third Caſe following--4445.3862. In the firſt Chiliad with the characterisk of 1, the neereſt to it is 1431.3637, which giveth 27 tenth parts. In the ſame Chilliad with the characterisk of 2, is 2444.0448, which giveth 278 hundred parts. In the third Chilliad with the characterisk of 3, is 3445.2928, which giveth 2788 thouſand parts. In the 28 Chilliad with the characterisk of 4, is 4445.3862, the number it ſelfe, which giveth 27886 ten thouſand parts.

7 In diſtinguiſhing whole numbers from fractions, I uſe a line, by which is ſignified whatſoever ſtandeth before it, to bee integers, in ſome caſes equall to the Radius, but that which

which is ſeparated by the line, to bee a part or fraction thereof. So is 0349 in the fourth Chapter a fraction ſignifying 349 thouſand parts of the Radius Z E, but in the number 2866 the figure 2 ſignifieth a line double to the Radius Z E, and 866 ſo many thouſand parts more of a Radius, and ſo in the reſt.

8 Note that though the proportionals be ſet down in the naturall way of Sines and Tangents and their complements, yet the numericall operation both for facility and brevity, is always performed by the artificiall numbers of Logarithms.

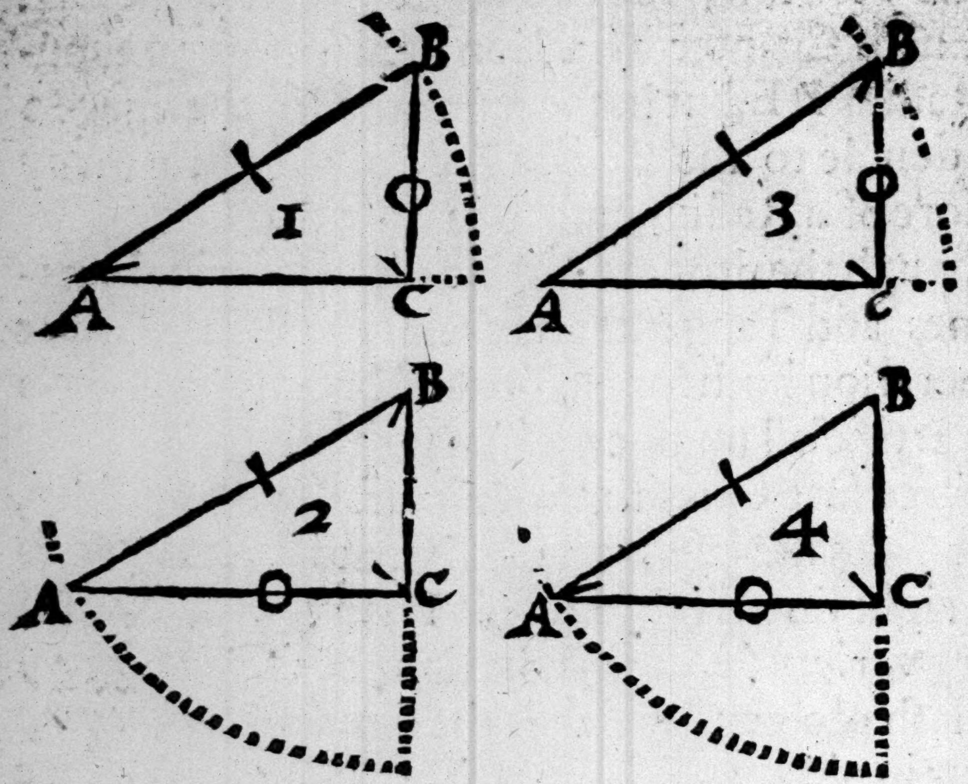
9 Laſtly, the three firſt Caſes following afford you the ſides, the fourth and fift Caſes the baſe, and the ſixt and ſeventh Caſes the angles of any right lined right angled Triangle, as by this mark o upon every variety (which is the ſigne of the *quæſitum*) and by this – the daſh of a pen (which is the ſigne of the *datum*) doth appeare: but in oblique Triangles the ſides and angles are promiſcuouſly found, and the caſes but few, to which I referre you.

Caſe 1. SIDES.

By the baſe and angles, to finde either ſide.

A Triangle conſiſteth of ſix parts, three ſides, and three angles, whereof any three being given, the reſt may be found, only excepting the three angles of a plane Triangle, by which the proportion may bee given, but no ſide can bee found, becauſe the three angles of one Triangle may bee equall to the three angles of another triangle, although their ſides bee altogether unequall.

The Radius, Sine, and complement of any arch: or Radius, Tangent, and Secant of any arch do make a right lined right angled Triangle. Wherefore let the plane Triangle A B C, right angled at C, repreſent the Triangle P L 4 of the fundamentall ſchem, *Chap.* 4. right angled at L, *viz.* A B the Radius P 4, C B the Sine of the oppoſite angle or leſſer ſide; L 4 and A C the Sine of the complement or greater ſide P L; or againe let A C repreſent the Radius P L, as in the ſecond caſe, B C the Tangent of the oppoſite angle or leſſer ſide L 4, and A B the Secant thereof P 4, let the baſe A B bee given 322, that is three inches and 22 hundred parts, and the angle at A 30 d, therefore the complement thereof at B 60 d. by the firſt of the ſecond of *Regiomont.*



to find the sides C A or C B in like parts of the base: if you make A B the Radius, then are C B & A C the Sines of their opposite angles A and B, as in the two first varieties, & the cosines of them, as in the two second varieties, wherfore

			Log.
As the Sine of A C B	90 d.	0'	10000.00
Is to the base A B in parts	3220		0507.85
So is the Sine of { B A C or A B C	30 d.	0'	9698.97
	60 d.	0'	9937.53
To the side { C B or C A	1610		10206.82
	2788		10445.38

Againe.

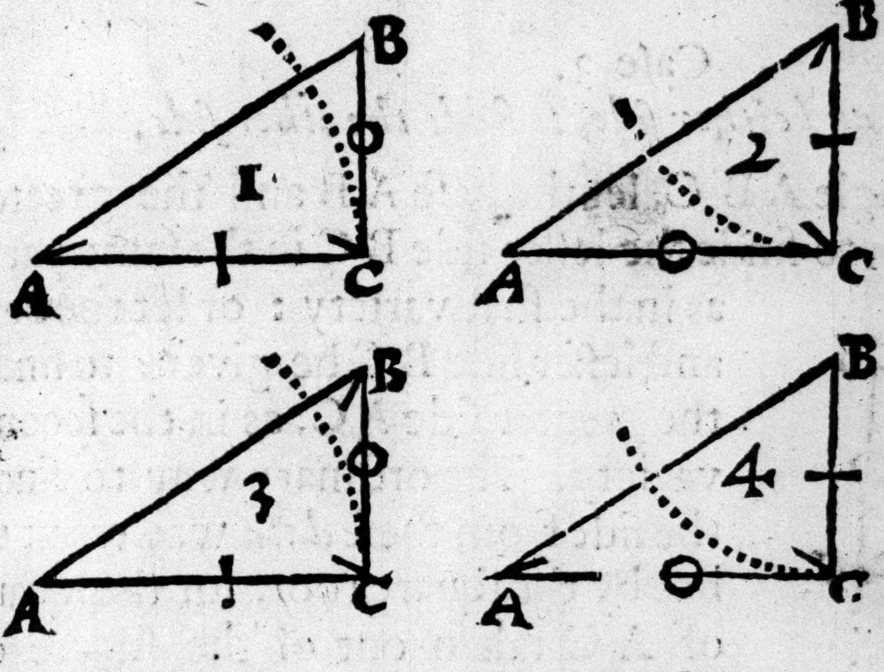
			Log.
As the Sine of A C B	90 d.	0'	10000.00
Is to the base A B	3220		0507.85
So is the cosine of { A B C or B A C	60 d.	0'	9698.97
	30 d.	0'	9937.53
To the side { C B or C A	1610		10206.82
	2788		10445.38

Case 2.

Case 2.

By the angles and either side, to finde the other side.

IN the same Triangle A B C let the greater side A C and the lesser angle at A be given, to finde the lesser side B C; or contrary, to finde the greater side A C. If you make A C in the first, and B C in the second the Radius, then are C B and C A the Tangents of their opposite angles A and B, as in the two first varieties, & the cotangents of them, as in the two later varieties; wherefore,



		Log.
As the Radius A C		10000.00
Is to C B the tangent of C A B 30 d. 0 m. or Cotangent of C B A 60. d. 0 m.		9761.44
So is the side A C in parts	2788	0445.38
To the side C B in parts	1610	10206.82

And

		Log.
As the Radius B C		10000.00
Is to C A the Tangent of C B A 60 d. 0 m. or Cotangent of C A B 30 d. 0 m.		10238.56
So is the side B C in parts	1610	0206.82
To the side A C in parts	2788	10445.38

This Case may bee also resolved by Sines alone, because the sides and Sines of the angles are proportionall, and the one acute angle

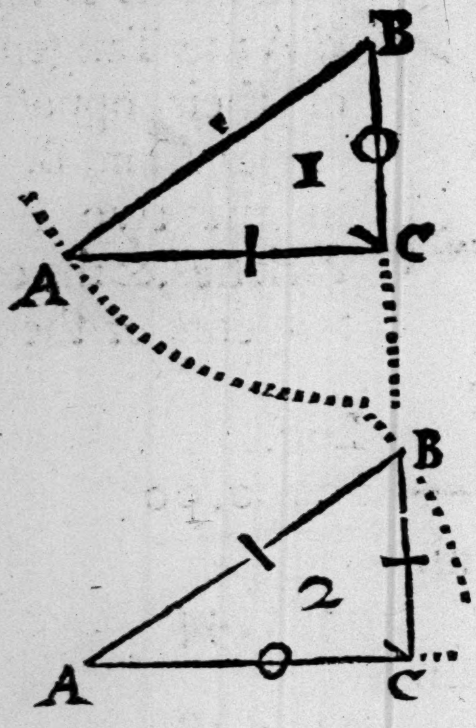
angle is alwayes complement to the other, by the 1 of the 2 of *Regiomontanus*, wherefore

As the Sine of A B C 60 d. 0′
is to the oppoſite ſide A C 2788
So is the Sine of A B C 30 d. 0′
to the oppoſite ſide B C 1610
} as in the third variety.

Caſe 3.

By the baſe and either ſide, to finde the other ſide.

IN the ſame Triangle A B C, let the baſe A B and the greater ſide A C be given, to finde the leſſer ſide B C in the ſame parts as in the firſt variety: or let the baſe and leſſer ſide B C be given, to finde the greater ſide A C, as in the ſecond variety. The ordinary way to finde the ſide from theſe *data* was wont to bee by the ſquare root, for the ſquare of A C taken out of the ſquare of A B, leaveth the ſquare of B C, whoſe ſquare root is the ſide B C deſired; but the eaſier way by Sines (if the numbers bee great) is thus performed at two works, for making A B the Radius, A C is the Sine of the angle B, as in the firſt, and B C the Sine of the angle A, as in the ſecond variety: wherefore



		Log.
As the baſe A B in parts	3220	0507.85
Is to the ſide {A C or B C} in parts.	2788	0445.38
	1610	0206.86
So is the ſine of A C B	90 d. 0′	10000.00
To the ſine of A B C	60 d. 0′	9937.53
Or to the ſine of B A C	30 d. 0′	9698.97

Secondly having the one angle, the other is complement thereof in both: wherefore

As

As the Sine of A C B 90 d. in both			10000.00
Is to the Sine of { B A C in the firſt		30 d. 0′	9698.97
and			
A B C in the ſecond		60 d. 0′	9937.97
So is the ſide A B in both		3200	0507.85
To the ſide { B C in the firſt		1610	10206.82
and			
A C in the ſecond		2788	10445.38

You may alſo performe the ſame more eaſily by the Chilliads alone, as in the ninteenth Chapter of Mr. *Brigs* his Arithmet. Logarithm. continuing A B and B A one place further, becauſe A C is 27886 parts.

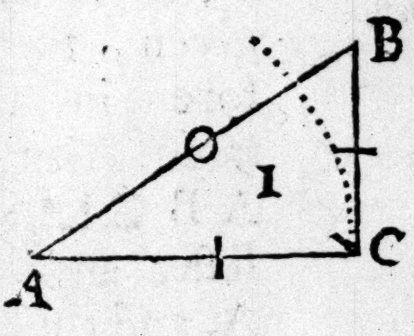
			Log.
The ſumme of A B and B C is	60086	+	0778.77
The difference of them is	4314	—	0365.12
The ſum of their Logarithms is			0413.65
Whoſe ½ is the ſide B C required	1610		0206.82

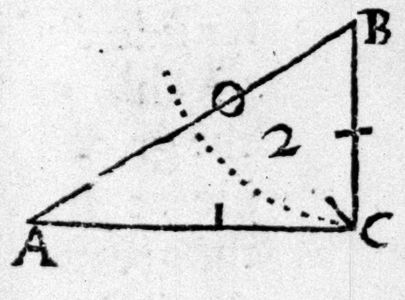
Note the Logarithme of the difference being defective, is ſubducted.

			Log.
The ſumme of A B and B C is	4830	+	0683.95
The difference of them is	1610	+	0206.82
The ſum of their Logarithms is			0890.77
Whoſe ½ is of the ſide A C deſired	2788		0445.38

Caſe 4. BASE.

By both the ſides, to finde the baſe.





IN the ſame Triangle A B C, let the ſides A C and C B bee given, to finde the baſe A B in the like parts. The ordinary way to finde the baſe from the *data* was wont to be by the ſquare root, for adding the ſquares of the two ſides A C and B C together, you have the ſquare of the baſe A B, whoſe ſquare root is the baſe deſired; but the eaſier way by Tangents (if the numbers bee great) is thus at two works, as afore: for making A C the Radius, B C is the Tangent

gent of the angle B A C, as in the first variety, and making B C the Radius, C A is the Tangent of the angle A B C, as in the second variety, wherefore.

		Log.
As the side A C in parts	2788	0445.38
Is to the side C B in parts	1610	0206.82
So is the line A C as Radius		10000.00
To the line C B as Tangent of the angle C A B	30 d. 0′	9761.44

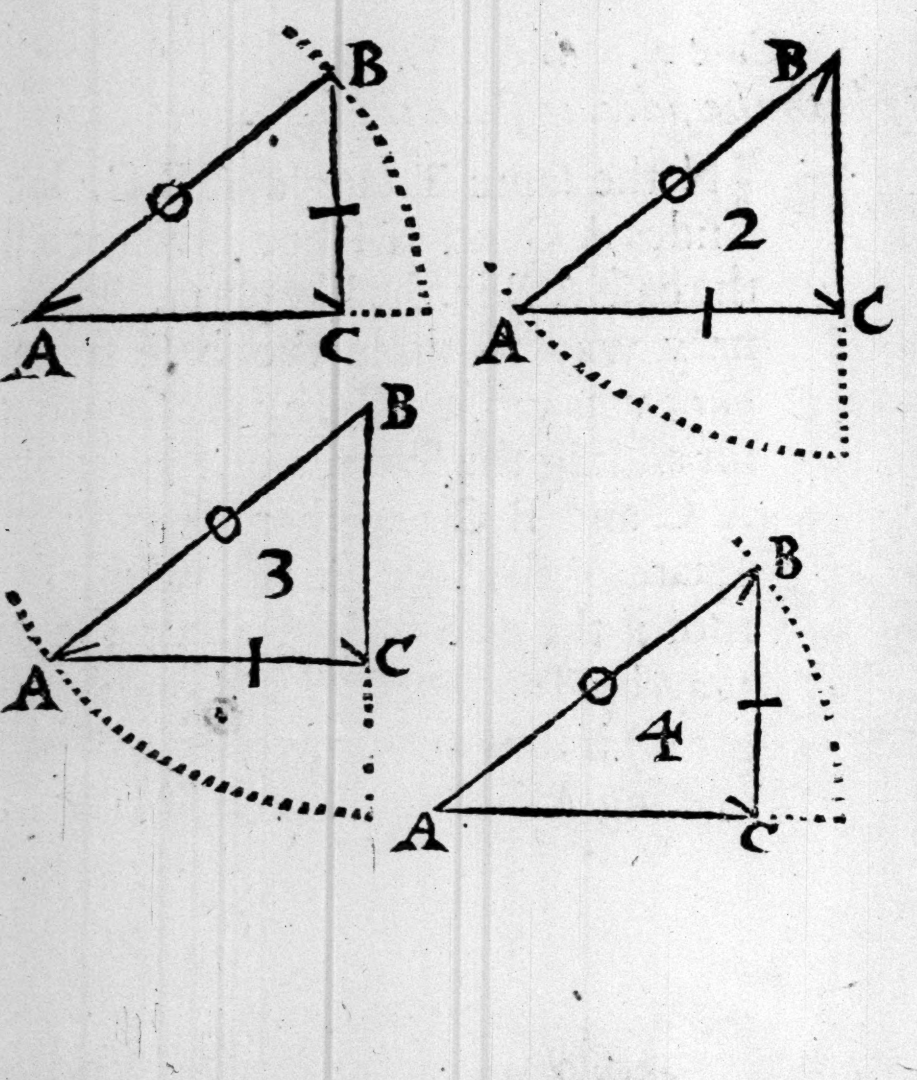
and so of the other variety for A C.

Secondly,

			Log.
As the Sine of	C A B or	30 d. 0′	9698.97
	C B A	60 d. 0′	9937.53
Is to the side	C B or	1610	0206.82
	C A	2788	0445.38
So is A C B the Sine of		90 d. 0′	10000.00
To the base A B		3220	0507.85

Case 5.

By the angles and either side, to finde the base.



If one angle be given, the other is also given, therefore in the same Triangle A B C let the lesser angle at A, and the lesser side B C be given, or let the greater angle at B, and the greater side A C be given; or

or contrary, to finde the base A B in the same parts. If you make A B the Radius, then are the sides B C and A C the Sines of their opposite angles A and B, as in the two first varieties, and the Cosines of them, as in the two second varieties, wherefore

			Log.
As the Sine of	B A C	30d. 0'	9698.97
	or		
	A B C	60d. 0'	9937.83
Is to the side	C B	1610	0206.82
	or		
	C A	2788	0445.38
So is the Sine of A C B		90d. 0'	10000.00
To the base	A B	3220	0507.85

And againe,

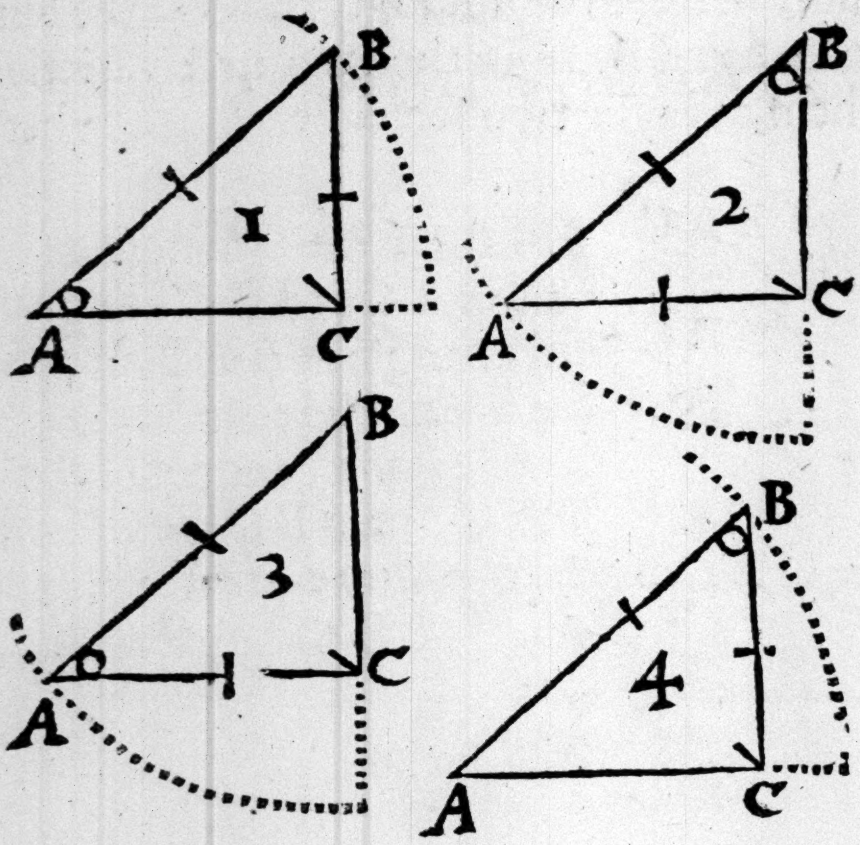
			Log.
As the cosine of	B A C	30d. 0'	9937.53
	or		
	A B C	60d. 0'	9698.97
Is to the side	A C	2788	0445.38
	or		
	B C	1610	0206.82
So is the sine of A C B		90d. 0'	10000.00
To the base	A B	3220	0507.85

Case 6. ANGLES.

By the base and either side, to finde an angle.

IN the same triangle A B *C*, let the base A B and the lesser side B *C* be given, to finde the lesser angle at A; or let the base and greater side A *C* bee given, to finde the greater angle at B; and contrary. If you make the base A B the Radius, then are the sides B *C* and A *C* the sines of the opposite angles A and B, as in the two first varieties, and the cosines of them, as in the two second varieties, wherefore

As



As the base A B	3220	0507.85
Is to the Sine of A C B	90 d. 0'	10000.00
So is the side { B C	1610	0206.82
or		
A C }	2788	0445.38
To the sine of the angle { B A C	30 d. 0'	9698.97
or		
A B C }	60 d. 0'	9937.53

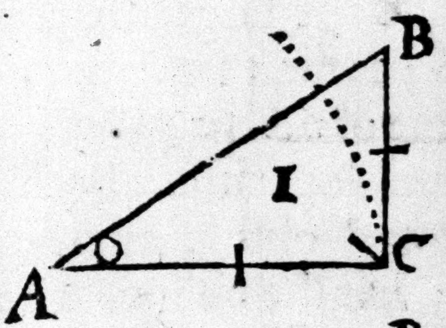
Againe,

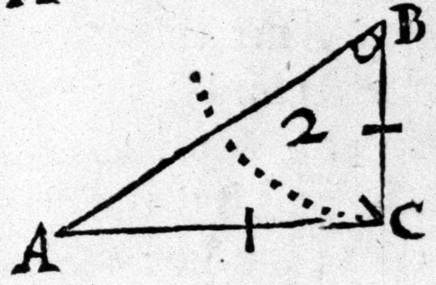
		Log.
As the base A B	3220	0507.85
Is to the Sine of A C B	90 d. 0'	10000.00
So is the side { A C	2788	0445.38
or		
B C }	1610	0206.82
To the cosine of the angle { A B C	60 d. 0'	9937.53
or		
B A C }	30 d. 0'	9698.97

Case

Case 7.

By both the sides, to finde either angle.





IN the same Triangle A B C, let the sides A *C* and B *C* bee given, to finde either angle at A or B. If you make A *C* the greater side the Radius, B *C* the lesser side is the Tangent of the lesser angle B A *C*, and if B *C* the lesser side be Radius, A *C* the greater side is the Tangent of A B *C* the greater angle: wherfore

		Log.
As the side A *C* in parts	2788	0445.38
Is to the side B *C* in parts	1610	0206.82
So is the side A *C* Radius		10000.00
To the side B *C* as Tangent of the angle B A *C*	30 d. 0'	9761.44

Againe,

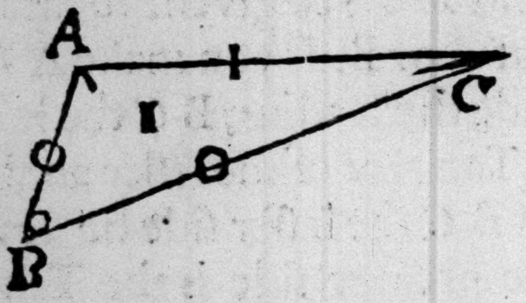
		Log.
As the side B *C* in parts	1610	0206.82
Is to the side A *C* in parts	2788	0445.38
So is the side B *C* Radius		10000.00
To the side A *C* as tangent of the angle A B *C*	60 d. 0'	10238.56

Case 1. OBLIQVE TRIANGLES.

By two angles and the side comprehended, to finde the third angle, and the other two sides.

IN oblique Triangles there are only foure cases, but many varieties, notwithstanding because they come seldome into use in

in this Treatise, and they are already learnedly demonstrated by *Mr. Henry Gellibrand in Trigonometria Britannica*, I will only give example of the *C*ases, and leave the varieties to every mans private practice; Therein is to be noted, that whensoever you deale with an obtuse angle, you must take the Logarithme of the complement thereof to a semicircle; as for 113 d. 31′ the Logarithme of *66* d. *29*′, because the sine and logarithme both of the acute and obtuse angle are the same; Let the oblique triangle A B *C* represent the triangle O B G in the second diagram of the 27 chapter; *vizt.* A *C* the axis of the stile O B, A B the lesser side O G, and B *C* the greater side B G, and let the angles at A 113 d. 31′, and at *C* 19 d. 25′, and the side A *C* 2033 be given, to finde the angle at B, and the sides A B and B *C*. The angle at B is 47 d. 4′, found without calculation, because the three angles of every right lined triangle are equall to two right angles, by the 32 p. 1. b. of *Euclid*, which being known, the sides are found by the 1 p. 2. b. of *Regiomontanus*, because the sides and sines of the opposite angles are proportionall one to the other; wherefore,

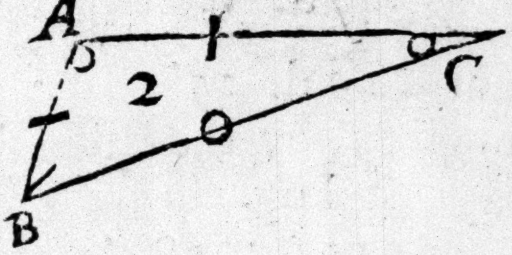


			Log.
As the sine of the angle A B *C*		47 d. 4′	0135.4018. arith. com.
Is to the sine of the side A *C*		2033	3308.1374
So is the ~~sine of the~~ angle	B A *C*	113 d. 31′.	9962.3428, or 66 d. 29′
	or		
	A *C* B	19 d. 25′	9521.7073
To the side	B *C*	2546	3405.8820
	or		
	B A	923	2965.2465.

*C*ase 2.

By any two sides and an angle opposite to one of them, to finde the other side and angles, if the species of the angle sought be known, because the same sine answereth both to the acute and obtuse angle.

In the same triangle A B *C*, let the side A B 923, and the side



side A C 2033, with the angle A B C 47 d. 4′ opposite thereto be given, to finde the angle A C B, by which the angle B A C is given, and the side B C: wherfore

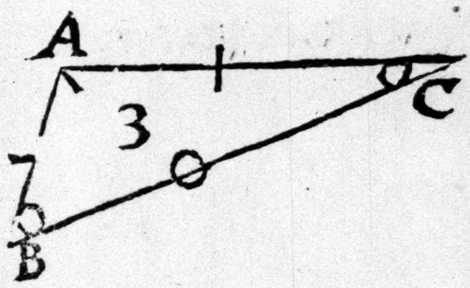
			Log.
As the side A C	2033		6691.8625
Is to the sine of the angle A B C	47 d.	4′	9864.5982
So is the side A B	923		2965.2465
To the sine of the angle A C B	19 d.	25′	x9521.7072

therefore B A C 113 d. 31′ the compl. of B and C to 180 d. Then is the side B C found by the later axiome of the former Case; for

			Log.
As the sine of A B C	47 d.	4′	0135.4018 Ar. compl.
Is to the side A C	2033		3308.1374
So is the sine of B A C	113 d.	31′	9962.3428
To the side B C	2546		x3405.8820

Case 3.

By two sides and the angle comprehended, to finde the third side, and other two angles.



IN the same triangle A B C let the side A C 2033, and the side A B 923, and the angle comprehended by them B A C 113 d. 31 bee given, to finde the angles B and C, and the third side B C; wherefore

		Log.
As the summe of the sides A B and A C	2956.	6529.2956
Is to the difference of them	1110	3045.3230
So is the tangent of ½ the summe of the unknown angles B & C, which are the complements of the angle A to 180 d,	33 d. 14′½	9816.5202
To the tangent of the difference of them	13 d. 49′½	x9391.1388

C which

which added to the $\frac{1}{2}$ summe, giveth the greater angle at B ——————— } 47 d. 4′
and subtracted from it, the lesser angle at C 19 d. 25′
The angles being found, the side is also given, by the last of the first Case; wherefore

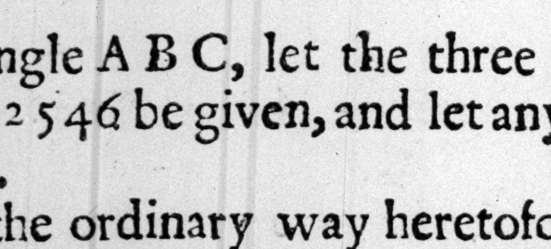
		Log.
As the sine of A B C	47 d. 4′	0135.4018. Ar.com.
Is to the side A C in parts	2033	3308.1374
So is the sine of B A C	113 d. 31′	9962.3428
To the side B C in parts	2546.	13405.8820

Case 4.

By the three sides, to finde any angle.

IN the same triangle A B C, let the three sides A B 923. *A C* 2033. and B C 2546 be given, and let any of the angles A, B, or C, be required.

In this Case the ordinary way heretofore hath been to reduce the oblique triangle into two right angled triangles, by raysing or letting fall the perpendicular A D from any angle (though most commodiously from the greatest) as here from A, whereby the two lesser sides B D and D C of each triangle A D B and A D C are found, and consequently the angles at A subtended by them, the complements whereof are the angles at B and C; but the better way is drawn out of the 18 chapter of Mr. *Briggs* his *Arithmetica Logarith.* which I received from him many yeeres since.



Out of the Semiperimeter of the three sides, subduct every side, so have you the differences; adde the arithmeticall complements of the logarith. of the semiperimeter and difference of the base, unto the logarithmes of the difference of the sides, halfe the summe of these foure logarithmes, is the logarithme of the tangent of halfe the angle desired.

The

		Three angles.
The base AB	923	A 113 d. 30′ 40″
the sides AC	2033	B 47 d. 4′ 20″
the sides BC	2546	C 19 d. 25′ 0

		Log.	
the summe	5502		
The halfe summe	2751	6560.5094	Arith. compl.
the differ. of the base	1828	6738.0238	Arith. compl.
the differ. of the sides	718	2856.1244	
the differ. of the sides	205	2311.7539	
	Totall	18466.4115	
	The halfe T.	9233.2057.	9 d. 42′ ½
		the double	19 d. 25′

Secondly,

		Log.	
The base AC	2033		
the sides AB	923		
the sides BC	2546		
the summe	5502		
the halfe summe	2751	6560.5094	Arith. compl.
the differ. of the base	718	7143.8756	Arith. compl.
the diffe. of the sides	1828	3261.9762	
the diffe. of the sides	205	2311.7539	
	Totall	19278.1151	
	the halfe T.	9639.0575.	23 d. 32′ 10″
		the double	47 d. 4′ 20″

Thirdly,

		Log.	
The base BC	2546		
the sides AC	2033		
the sides AB	923		
the summe	5502		
the halfe summe	2751	6560.5094	Arith. compl.
the differ. of the base	205	7688.2461	Arith. compl.
the differ. of the sides	1828	3261.9762	
the differ. of the sides	718	2856.1244	
	Totall	20366.8561	
	the halfe T.	10183.4280	56 d. 45′ 20″
		the double	113 d. 30 40

CHAP. III.

The severall Cases and varieties of sphericall triangles, with divers cautions to be observed in the practice of them.

1 WHereas in the practice of the Cases I sometimes use but six figures, and the Canon consists of eight, it is left at liberty to use all or some of them, only in cases falling neere the beginning and end of the quadrant, or in resolving the same question by severall cases except you use all the figures, and take the fourth proportionall as they arise, and fit the Logar. of the sines, cosines, tangents and cotangents unto them, as is done in the table following, the numbers will not agree exactly in all the cases.

2 When the Logarithme of the fourth proportionall exceedeth 9 in the first place, you must cancell the rest, unlesse it produce a Tangent above 45 d. which is greater than the *Radius*.

3 If the *Radius* be one of the middle termes, you may avoid subtraction, by taking the Arith. complement of the Logar. sine of the first proportionall for the sine it selfe, and the Logar. tangent of the complement for the tangent it selfe, and adde all three together; notwithstanding because it is easie to subtract the first number out of the summe of the second and third (if the *Radius* be one of them) as to adde all together, I forbeare to use the help of addition; but in cases where the *Radius* is none of the three proportionals given.

4 All verticall triangles have the sines of the *hypotenusas* and perpendiculars, by the first; the sines of the base and tangents of the perpendiculars, by the 2 axiom of the 4 b. of *Pitiscus*, proportionall, and the angles at their mutuall intersections equall by the 15 p. of 1 b. of *Euclid*. So may you finde in the first variety of the second case the angle P ♉ ♋ and ♈ ♉ R. or P ♉ ♈, and ♋ ♉ R equall, and the like sides of the one triangle ♉ P ♋ proportionall to the like of the other ♉ ♈ R, which will shorten the work in many cases.

5 It

5 It may be here again noted, that though the chiliades bee properly applyed to plane triangles, the Canon to ſphericall, yet becauſe every log. canon is made out of the chiliades, the want of a canon may bee ſupplied by the chiliades, for if you take the Logarith. of the naturall ſines and tangents of the ſides and angles given, as if they were abſolute numbers, the fourth proportionall will be alſo an abſolute number, which found in the table of naturall ſines and tangents, reſolveth the queſtion without help of the Canon.

6 Becauſe Authours differ in the termes of a R. S. triangle, ſome calling the ſide ſubtending the right angle, the *hypotenuſa*, other the baſe; and the ſides including the right angle, the perpendicular and baſe, other the legs, it is indifferent which be uſed, ſo they be not promiſcuouſly taken in the ſame Caſe, therein the greateſt difficulty is, when to uſe the ſines alone, and when the ſines and tangents together: Whenſoever therefore you deale with the baſe and either ſide including the acute angle, you muſt work by ſines; when with the two ſides including the right angle, by ſines and tangents together, as in the continuation of the ſides will plainly appeare, ſo have you in the firſt variety of the firſt caſe: as the ſine of ♈ ♋, is to the ſine of ♋ Æ, ſo is the ſine of ♈ ♉, to the ſine of ♉ R: but in the firſt variety of the fift caſe: as the ſine of ♈ Æ, is to the tangent of Æ ♋, ſo is the ſine of ♈ R, to the tangent of R ♉, and thus of the reſt.

7 In R. S. triangles there are ſixteen caſes and thirty varieties, the firſt varieties of the firſt ſix caſes give the leſſer ſides, the 2nd varieties the greater ſides, the ſeventh, eighth, ninth, and tenth caſes the baſe, the firſt varieties of the later ſix caſes give the leſſer angles, the ſecond varieties the greater, as by the ſines of the *data* and *quæſita* doth appeare; of each whereof for more plaineſſe ſake, a particular example ſhall be given.

In the diagram following, P ♋ Æ R ♈, let P repreſent the North Pole, P ♋ Æ the ſolſtitiall colure, P ♉ R a meridian or great circle paſſing through the beginning of ♉, let ♈ bee the interſection of the Equator and Ecliptique, ♈ R Æ 90 d. of the Equator, and ♈ ♉ ♋ 90 d. of the Ecliptique.

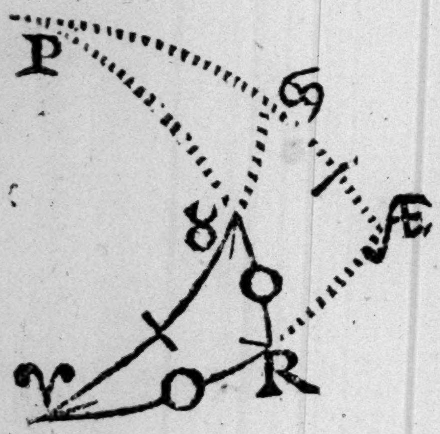
	d ′ ″	Sine	Cosine	
Side	11.30.43 $\frac{1}{2}$.	Si.9300.1052.	Cos.9991.1740	The severall parts of the Triangle ♈ R ♉.
Angle	23.31.30	Si.9601.1352.	Cos.9962.3153	
Sides	27.53.42 $\frac{1}{2}$.	Si.9670.1111.	Cos.9946.3565	
	30. 0. 0	Si.9698.9700.	Cos.9937.5306	
Angle	69.20.35 $\frac{1}{3}$.	Si.9971.1413.	Cos.9547.4918	

	d ′ ″	Tangent	Cotangent	
Side	11.30.43 $\frac{1}{2}$.	T. 9308.9312.	Cot.10691.0688	The severall parts of the Trian. ♈ R ♉
Angle	23.31.30	T. 9638.8199.	Cot.10361.1801	
Sides	27.53.42 $\frac{1}{2}$.	T. 9723.7546.	Cot.10276.2454	
	30. 0. 0.	T. 9761.4393.	Cot.10238.5606	
Angle	69.20.35 $\frac{1}{3}$.	T.10423.6495.	Cot. 9576.3505	

Case 1. SIDES.

By the base and angle opposite to the side sought, to finde either side.

IN the triangle adjoyning ♈ R ♉, let the base ♈ ♉ bee given 30 d. the distance of the Sunne from the Equinoctiall point, and let the angle ♈ bee given, whose measure is Æ ♋, 23 d. 31′ 30″, the greatest declination of the Sunne, with the right angle at R, alwayes 90 d. to finde the lesser side ♉ R the declination of the Sunne in the beginning of ♉. If you continue the sides to quadrants, then the proportion is,



		Log.
As the whole sine ♈ ♋	90 d. 0′ 0″	10000.0000
Is to the sine ♋ Æ, the measure of the angle ♈	23 d. 31′ 30″	9601.1352
So is the sine of the base ♈ ♉	30 d. 00′ 00″	9698.9700
To the sine of the side ♉ R	11 d. 30′ 43″ $\frac{1}{2}$	9300.1052

The declination of the Sunne in 0 d. of ♉.

But if you will finde the greater side ♈ R, then instead of the angle

angle at ♈, let the angle at ♉ be given, *69* d. 20′ 35″ ⅓ which is the angle that the Ecliptique maketh with the great circle passing by the declination of the Sun. The same Canon resolveth the question, without continuation of the sides, because the sines of the sides and opposite angles are proportionall, by the 16 of the 4 b. of *Regiomontanus*.

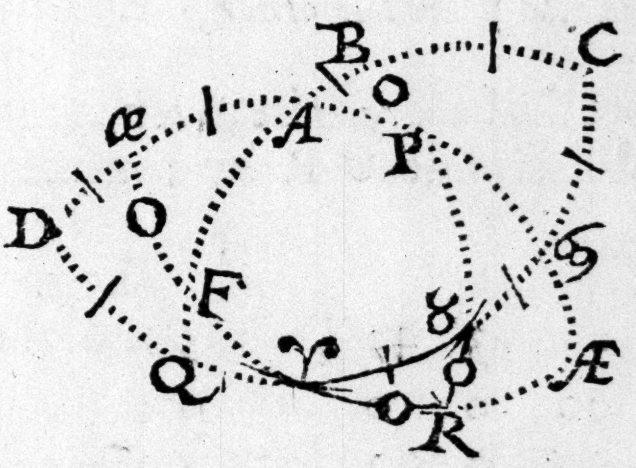
	d			Log.
As the sine of ♈ R ♉	90	0′	0″	10000.0000
Is to the sine of the base ♈ ♉	30	0	0	9698.9700
So is the sine of the angle ♈ ♉ R	69	20	35 ⅓	9971.1413
To the sine of the side ♈ R	27	53	42 ½	✗9670.1113

The right ascension of the Sunne in the same place.

Case 2.

By the base and angle adjacent to the side sought, to finde either side.

IN the same triangle ♈ R ♉ let the base ♈ ♉ bee given as afore, and the angle at ♉ adjacent to the side sought, to finde the lesser side ♉ R. Because there are not sufficient *data* in this triangle, continue the sides unto quadrants, and further if there be cause, *vizt.* ♈ ♉ to C, R ♉ to B, and Æ ♋ to A, then will ♋ C be equall to ♈ ♉, C B the measure of the angle ♉, A B the complement of that angle, and B P equall to ♉ R the side which is sought, and so in the rest that follow: wherefore,



	d.			Log.
As the whole sine A C	90	0′	0″	10000.0000
Is to the tang. of C ♋ equall to ♈ ♉	30	0	0	9761.4393
So is A B the cosine of the ang. ♉	69	20	35 ⅓	9547.4918
To the tang. of B P equall to ♉ R	11	30	43 ½	✗9308.9311

The Suns declination.

Secondly

Secondly, instead of the angle at ♉, let the angle at ♈ bee given, to finde the greater side ♈ R by continuation the other way: for ♈ ♉ is given, therefore ♈ Q and Q D, also the angle at ♈ is given, therefore the measure thereof D œ, and also œ A: wherefore,

				Log.
As the whole sine A D	90	0′	0″	10000.0000
Is to the tangent of D Q equall to the base ♈ ♉	30	0	0	9761.4393
So is A œ the cosine of the angle ♈	23	31	30	9962.3153
To the tangent of œ F equal to the side ♈ R the right ascension	27	53	42½	19723.7546

Otherwise by complement.

As the Sine of P ♋,
Is to the Tangent of ♋ ♉;
So is the whole Sine P Æ,
To the Tangent of Æ R the complement of R ♈ the right ascention.

Case 3.

By the base and either side, to finde the other side.

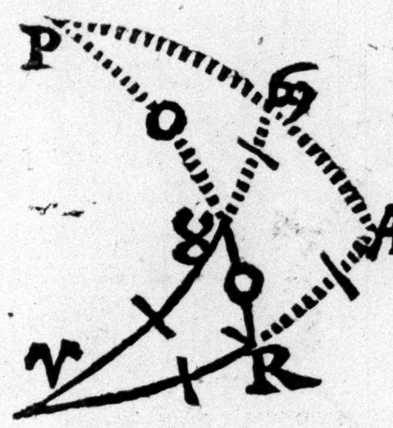
IN the same triangle ♈ R ♉, let the base ♈ ♉ be given, and the greater side ♈ R, to finde the lesser side ♉ R by continuation, &c.

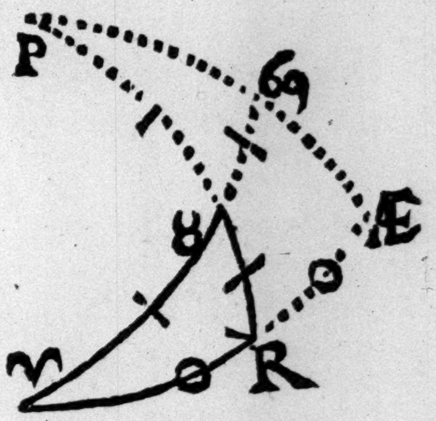
				Log.
As Æ R the cosine of ♈ R	27ᵈ	53′	42″½	9946.3565
Is to the whole sine R P	90	0	0	10000.0000
So is ♋ ♉ the cosine of ♈ ♉	30	0	00	9937.5306
To ♉ P the cosine of ♉ R	11	30	43½	9991.1741

Or if you will avoid subtraction, take the Arithmeticall complement of 27ᵈ. 53′ 42″½, *which is* 0053.6435, *and adde all together.*

Secondly, let the base ♈ ♉ bee given, and the lesser side ♉ R, to finde the greater side ♈ R by continuation &c.

As





				Log.
As P ♉ the cosine of ♉ R	11^d	30′	43″$\frac{1}{2}$	9991.1740
Is to ♉ ♋ the cosine of ♈ ♉	30	0	00	9937.5306
So is the whole sine P R	90	0	00	10000.0000
To R Æ the cosine of ♈ R.	27	53	42$\frac{1}{2}$	9946.3566

The Suns right ascention.

Case 4.

By either side and the angle opposite unto it, to finde the other side.

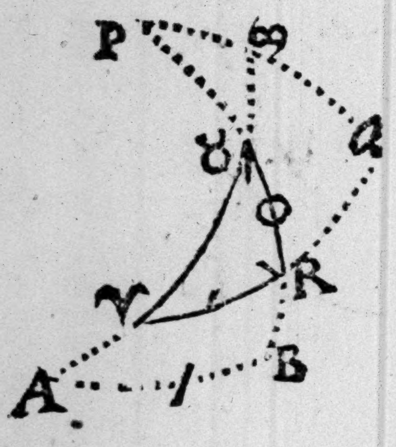
IN the same triangle ♈ R ♉, let the side ♈ R bee given, and the angle ♉ opposite thereunto, to find the side ♉ R: Continue the sides ♈ ♉ and ♉ R to quadrants, and A B shall bee the measure of the angle at ♉.

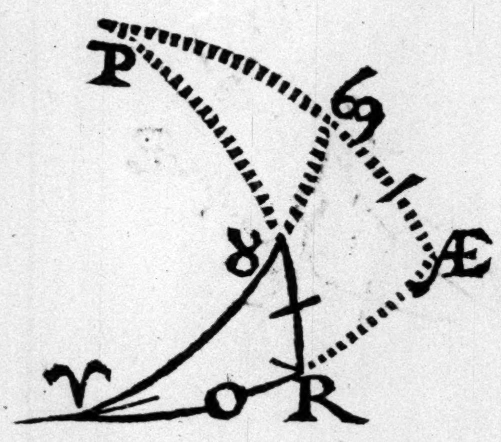
				Log.
As A B the tang. of the angle A ♉ B	69^d	20′	35″$\frac{1}{3}$	10423.6495
Is to the whole sine B ♉	90	0	0	10000.0000
So is the tangent of ♈ R	27	53	42$\frac{1}{2}$	9723.7546
To the sine of R ♉	11	30	43$\frac{1}{2}$	9300.1051

Or if you will avoyd subtraction, instead of the Tangent of 69*d.* 20′ 35″$\frac{1}{3}$, *take the complement thereof,* 9576.3505, *and adde all together.*

Secondly, instead of the angle ♉ and the side ♈ R, let the angle ♈ and the side ♉ R be given, and the side ♈ R be sought by continuation, &c.

As





					Log.
As the Tangent of ♋ Æ the measure of the angle ♋ ♈ Æ	}	23d.	31'	30"	9638.8199
Is to the whole Sine Æ ♈		90	0	00	10000.0000
So is the tang. of the lesser side ♉ R		11	30	43½	9308.9312
To the Sine of the greater side R ♈		27	53	42½	9670.1113

The Suns right ascention.

Case 5.

By either side and the angle opposite to the side sought, to finde the other side.

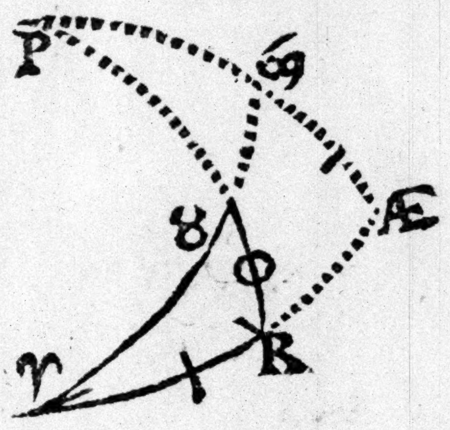
IN the same Triangle ♈ R ♉, let the angle ♈ be given, and the side ♈ R, to finde the side ♉ R opposite to the angle given, by continuation, &c.

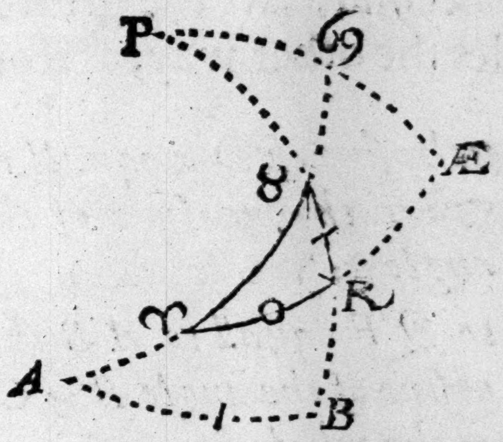
				Log.
As the whole Sine ♈ Æ	90d.	0'	0"	10000.0000
Is to Æ ♋ the tang. of the angle ♈	23	31	30	9638.8199
So is the Sine of the side given ♈ R	27	53	42½	9670.1111
To the tang. of the side sought R ♉	11	30	43½	19308.9310

The Suns declination.

Secondly, instead of the angle ♈ and the side ♈ R, let the angle ♉ be given, with the side ♉ R, and the other side ♈ R be sought: continue the sides, &c.

As





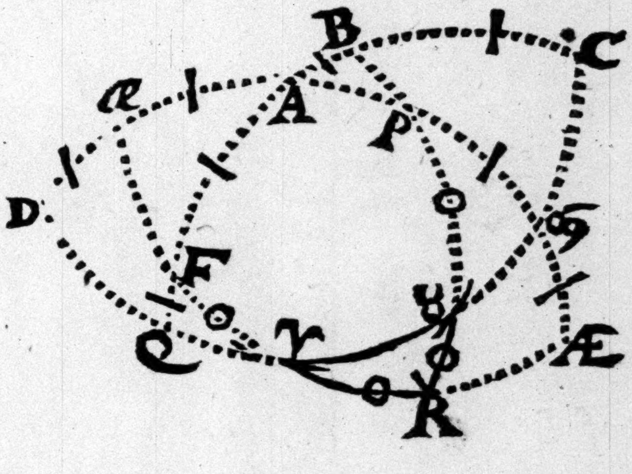
			Log.
As the whole sine ♉ B		90^d. 0' 0"	10000.0000
Is to B A the tang. of the angle A♉B		69 20 35⅓	10423.6495
So is the sine of the side given ♉ R		11 30 43½	9300.1052
To the tang. of the side sought R ♈		27 53 42½	9723.7547

The Suns right ascention.

Case 6.

By both the oblique angles, to finde either of the sides.

IN the same Triangle ♈ R ♉, let the angles at ♈ and ♉ be given, and let the lesser side ♉ R bee sought: continue the sides as afore.



		Log.
As B C the sine of the angle B ♉ C	69^d.20'35"⅓	9971.1413
Is to the whole sine B ♉	90 0 0	10000.0000
So is ♋ P the cosine of the angle ♋ ♈ Æ	23 31 30	9962.3153
To P ♉ the cosine of the side ♉ R	11 30 43½	9991.1740

The Suns declination.

Secondly

Secondly, let the greater side ♈ R be sought: continue the sides the other way, as afore.

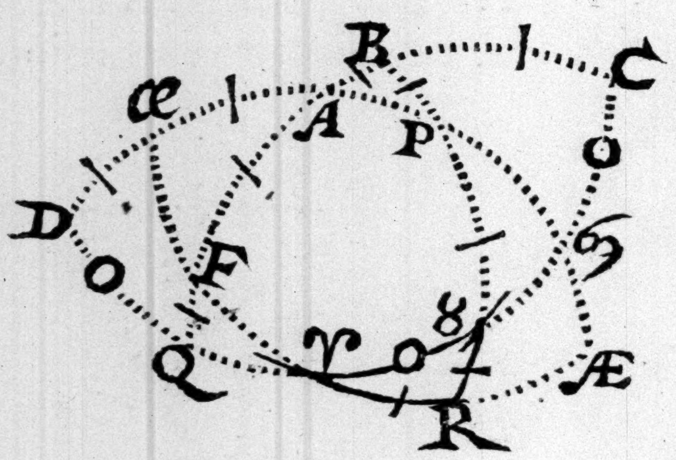
		Log.
As the sine of D a equall to ♋ Æ the measure of the angle ♋ ♈ Æ	23d. 31′ 30″	9601.1352
Is to Q F equall to A B the cosine of the angle B ♉ C	69 20 35 ⅓	9547 4918
So is the whole sine a ♈	90 00 00	10000 0000
To F ♈ the cosine of the side R ♈	27 53 42 ½	9946.3566

The Suns right ascention as afore.

Case 7. BASE.

By either side and the angle adjacent, to finde the base.

IN the same triangle ♈ R ♉, let the side ♉ R bee given, and the angle ♉ adjacent thereunto, and let the base ♈ ♉ bee sought: continue the sides for want of sufficient *data*.



		Log.
As A B the cosine of B ♉ C,	69d. 20′ 35 ⅓	9547.4918
Is to the tangent of B P equall to ♉ R	11 30 43 ⅓	9308 9312
So is the whole sine A C	90 0 0	10000.0000
To the tangent of C ♋ equall to ♈ ♉	30 0 0	9761.4394

The distance of the Sunne from ♈.

Secondly

Secondly, instead of the greater angle ♉ and the lesser side ♉ R, let the lesser angle ♈ and the greater side ♈ R bee given: continue the sides as afore.

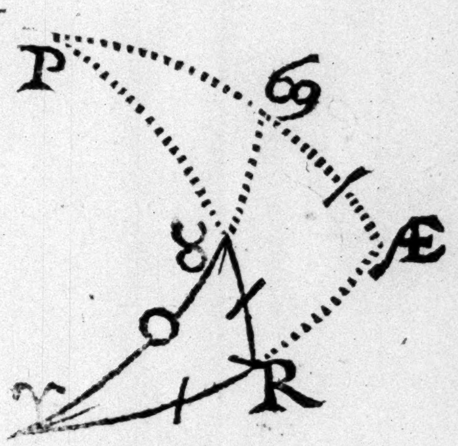
		Log.
As Aæ, equall to P ♋ the cosine of ♋ ♈ Æ	$23^{d}.31' \ 30''$	9962.3153
Is to the tangent æ F, equall to ♉ ♈	27 53 $42\frac{1}{2}$	9723.7546
So is the whole sine A D	90 00 00	10000.0000
To the tangent of D Q equall to ♈ ♉	30 00 00	9761.4393

The same distance againe.

Case 8.

By either side and the angle opposite thereunto, to finde the base.

IN the same triangle ♈ R ♉, let the lesser side ♉ R be given, and the angle ♈ opposite thereunto, to finde the base ♈ ♉, by continuation as afore.



		Log.
As the sine of Æ ♋ the measure of the angle ♈	$23^{d}.31' \ 30''$	9601.1353
Is to the whole sine ♋ ♈	90 00 00	10000.0000
So is the sine of the side ♉ R	11 30 $43\frac{1}{2}$	9300.1052
To the sine of the base ♉ ♈	30 00 00	9698.8700

The distance of the Sunne from ♈

Secondly,

Secondly let the greater ſide ♈ R bee given, and the greater angle ♉ oppoſite thereunto, without continuation.

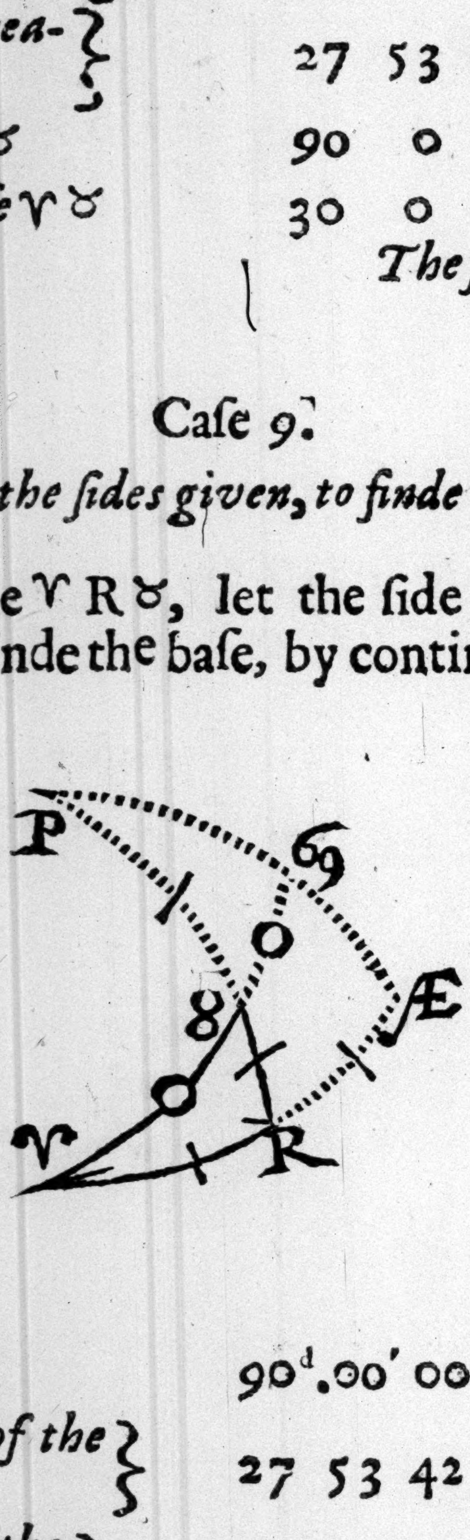
		Log.
As the ſine of the greater angle ♈ ♉ *R*	69d.20′ 35″ $\frac{1}{3}$	9971.1413
Is to the ſine of the greater ſide ♈ R	27 53 42 $\frac{1}{2}$	9670.1111
So is the ſine of ♈ R ♉	90 0 0	10000.0000
To the ſine of the baſe ♈ ♉	30 0 0	9698.9698

The ſame diſtance againe.

Caſe 9.

By both the ſides given, to finde the baſe.

IN the ſame Triangle ♈ R ♉, let the ſide ♉ R, and the ſide ♈ R be given, to finde the baſe, by continuation as afore.



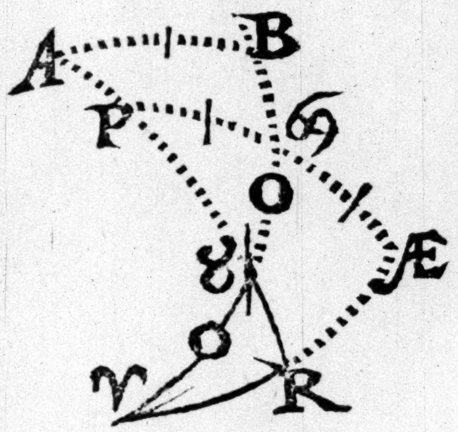
		Log.
As the whole ſine P R	90d.00′ 00″	10000.0000
Is to R Æ the coſine of the greater ſide ♈ *R*	27 53 42 $\frac{1}{2}$	9946.3565
So is P ♉ *the coſine of the leſſer ſide* ♉ *R*	11 30 43 $\frac{1}{2}$	9991.1740
To ♉ ♋ *the coſine of the baſe* ♈ ♉	30 00 00	9937.5305

The Suns diſtance from ♈ *as afore.*

Caſe

Case 10.

By both the oblique angles, to finde the base.



IN the same triangle ♈ R ♉, let the angle at ♉ and the angle at ♈ be given, to finde the base ♈ ♉: continue the sides for want of sufficient *data*.

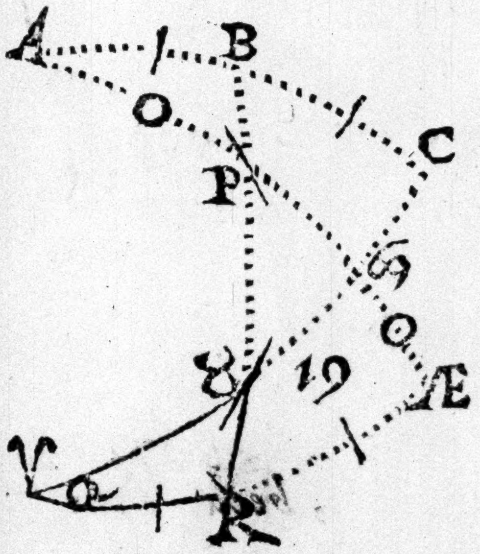
		Log.
As the tang. of A B the measure of the greater angle B ♉ A	69^{d}.20′ 35″$\frac{1}{3}$	10423.6495
Is to the whole sine B ♉	90 0 0	10000.0000
So is P ♋ the cotangent of the lesser angle ♋ ♈ Æ	23 31 30	10361.1801
To ♋ ♉ the cosine of the base ♈ ♉	30 0 0	9937.5306

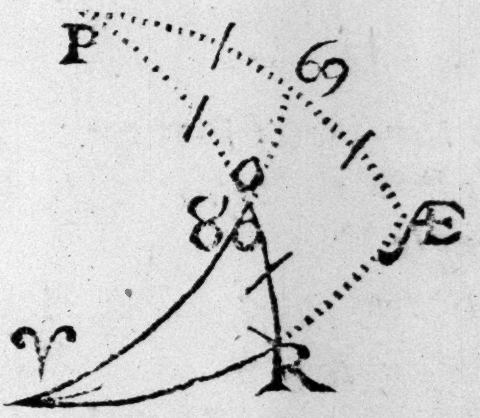
The same distance of the Sunne againe.

Case 11. ANGLES.

By either side and the angle opposite thereto, to finde the other angle.

IN the same triangle ♈ R ♉, let the greater side ♈ R and the greater angle ♉ opposite thereto bee given, to finde the lesser angle adjacent to the sides given: continue the sides as formerly.





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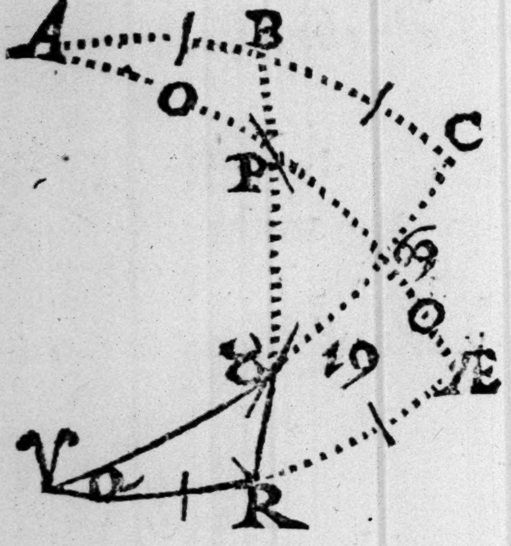
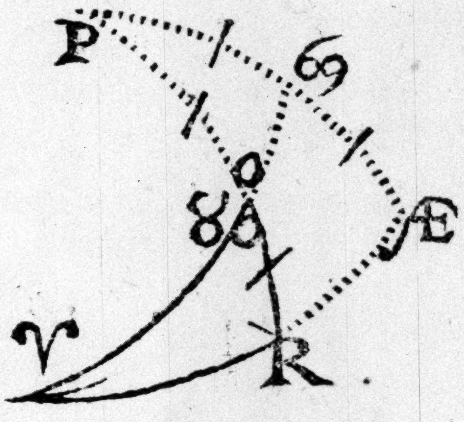




As A P B, whose measure is R Æ, the cosine of the greater side ♈ R	$27^{d}.53' \, 43'' \frac{1}{2}$	9946.3565
Is to A B the cosine of the greater angle B ♉ C	69 20 $35\frac{1}{3}$	9547.4918
So is the sine of A B P	90 00 00	10000.0000
To the sine of A P equall to ♋ Æ the measure of the angle ♋ ♈ Æ	23 31 30	9601.1353

The greatest declination of the Sunne.

Secondly, let the lesser side ♉ R be given, and the lesser angle ♈ opposite thereto, to finde the greater angle ♉ adjacent to the side given, by continuation as afore.

		Log.
As P ♉ the cosine of the lesser side ♉ R	$11^{d}.30' \, 43'' \frac{1}{2}$	9991.1740
Is to the sine of P ♋ ♉	90 00 00	10000.0000
So is P ♋ the cosine of the lesser angle ♈	23 31 30	9962.3153
To P ♉ ♋ the sine of the greater angle ♉ ♋	69 20 35	9971.1413

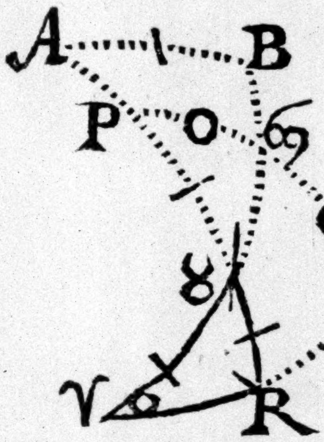
The angle of the ecliptick and meridian, because the two verticall angles be the same.

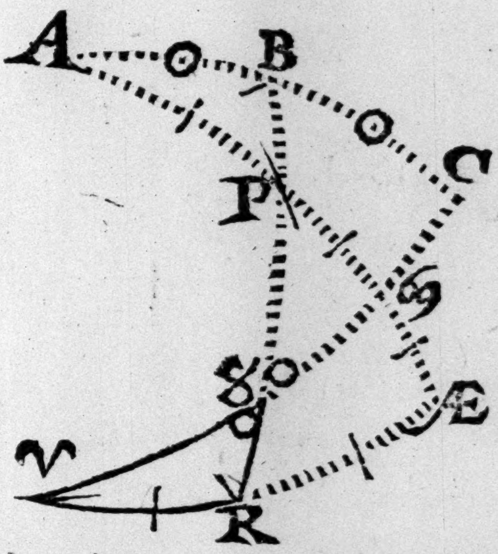
Case

Case 12.

By either side and the angle adjacent to it, to finde the angle opposite to that side.

IN the same triangle ♈ R ♉, let the greater angle ♉ bee given, and the lesser side ♉ R, to finde the lesser angle ♈ opposite thereto: continue the sides as formerly.





As the whole sine ♉ A	90d.00′ 00″	10000.0000
Is to ♉ P the cosine of the lesser side ♉ R	11 30 43 ½	9991.1740
So is A B the sine of the greater angle A ♉ B	69 20 35 ⅓	9971.1413
To P ♋ the cosine of ♋ Æ the measure of the lesser angle ♋ ♈ Æ	23 31 30	19962.3153

The greatest declination of the Sunne as afore.

Secondly, let the lesser angle ♈ and the greater side ♈ R bee given, to finde the greater angle ♉ opposite thereto, by continuation as afore.

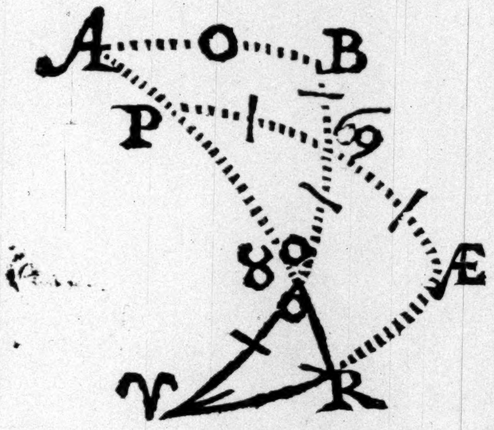
As the sine of A B P	90d.00′ 00″	10000.0000
Is to the sine of A P equall to ♋ Æ the measure of the lesser angle ♈	23 31 30	9601.1353
So is the sine of A P B whose measure is R Æ the cosine of the greater side ♈ R	27 53 42 ½	9946.3565
To A B the cosine of B C the measure of the greater angle ♉	69 20 35 ⅓	19547.4918

The angle of the ecliptick and meridian as afore.

Case 13.

By the base and one angle, to finde the other angle.

IN the same triangle ♈ R ♉, let the base ♈ ♉ be given, and the greater angle ♉, to finde the lesser angle ♈ : continue the sides as formerly.



		Log.
As the whole sine ♉ B	90^d.00′ 00″	10000.0000
Is to ♉ ♋ the cosine of the base ♈ ♉	30 00 00	9937.5306
So is the tangent of B A the measure of the greater angle ♉	69 20 $35\frac{1}{3}$	10423.6495
To P ♋ the cotangent of ♋ Æ the measure of the lesser angle ♈	23 31 30	10361.1801

The greatest declination as afore.

Secondly, let the base ♈ ♉ and the lesser angle ♈ be given, to finde the greater angle ♉, by continuation, &c.

		Log.
As ♉ ♋ the cosine of the base ♈ ♉	30^d.00′ 00″	9937.5306
Is to P ♋ the cotangent of ♋ Æ the measure of the angle ♈	23 31 30	10361.1801
So is the whole sine ♉ B	90 00 00	10000.0000
To the tangent of B A the measure of the greater angle ♉	69 20 $35\frac{1}{3}$	10423.6495

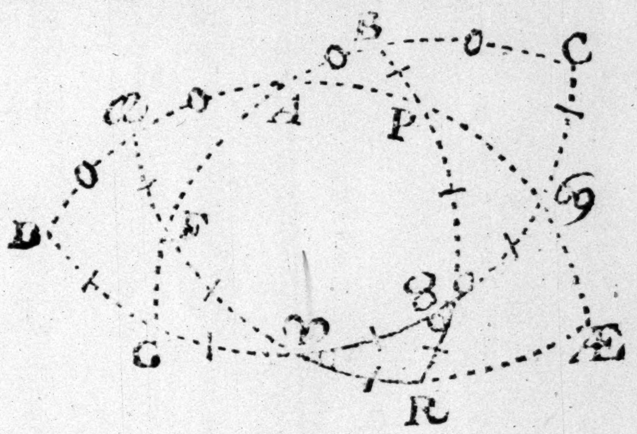
The angle of the meridian and ecliptick.

Case 14.

Case 14.

By the base and either side, to finde the angle comprehended by them.

IN the same triangle ♈ R ♉, let the base ♈ ♉ and the greater side ♈ R be given, to finde the lesser angle ♈ comprehended by them: continue the sides as formerly.



		Log.
As the tangent of G D equall to ♈ ♉	30^d. 0′ 0″	9761.4393
Is to the whole sine D A	90 0 0	10000.0000
So is the tangent of F æ equall to ♈ R	27 53 42½	9723.7546
To æ A the cosine of æ D equall to Æ ♋ the measure of the angle ♈	23 31 30	9962.3153

The greatest declination as afore: or as tangent R Æ is to the sine Æ P, so is the tangent ♉ ♋ to the sine ♋ P.

Secondly, let the base ♈ ♉ and the lesser side ♉ R bee given, to finde the greater angle ♉ comprehended by them; by continuation of the sides as afore.

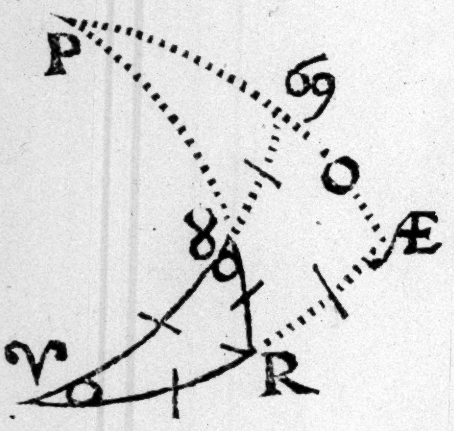
		Log.
As the tangent of ♋ C equall to the base ♈ ♉	30^d.00′ 00″	9761.4393
Is to the whole sine C Æ	90 00 00	10000.0000
So is the tangent of P B equall to the side ♉ R	11 30 43½	9308.9312
To B A the cosine of B C the measure of the greater angle ♉	69 20 35⅓	9547.4919

The angle of the meridian and ecliptick.

Case 15.

By the base and either side, to finde the angle opposite to that si

IN the same triangle ♈ R ♉, let the base bee given ♈♉, an
the lesser side ♉ R, to finde the lesser angle ♈ opposite theret
by continuation of the sides, as afore.



		Logar.
As the sine of the base ♈ ♉	30d 0′ 0″	9698.970
Is to the sine of the lesser side ♉ R	11 30 43 ½	9300.105
So is the whole sine ♈ ♋	90 0 0	10000.000
To to the sine of ♋ Æ the measure of the lesser angle ♈	23 31 30	9601.135

The Sunnes greatest declination

Secondly let the base ♈ ♉, and the greater side ♈ R be given
to finde the greater angle ♉ opposite thereto, without conti-
nuation, &c.

		Logar.
As the sine of the base ♈ ♉	30d 00′ 00″	9698.9700
Is to the sine of ♈ R ♉	90 00 00	10000.0000
So is the sine of the greater side ♈ R	27 53 42 ½	9670.1111
To the sine of the greater angle ♈ ♉ R	69 20 35 ⅓	9971.1411

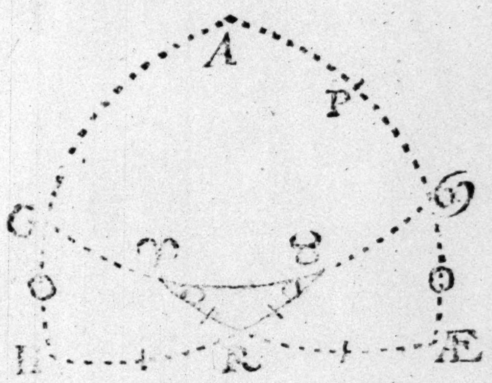
The angle of the ecliptick and meridian, as afore

Case

Case 16.

By both the sides, to finde either oblique angle.

IN the same triangle ♈ R ♉, let the greater side ♈ R, and the lesser side ♉ R be both given, to finde the lesser angle ♈: continue the sides as formerly.



		Logar.
As the sine of the greater side ♈ R	27^{d} 53′ 42″ ½	9670.1111
Is to the tangent of the lesser side ♉ R	11 30 43 ½	9308.9312
So is the whole sine ♈ Æ	90 00 00	10000.0000
To the tang. of Æ ♋ the measure of the lesser angle ♈	23 31 30	9638.8201

The Sunnes greatest declination as afore.

Secondly, let both sides be given, as afore, and the greater angle ♉ be sought, by continuation as formerly.

		Logar.
As the sine of the lesser side ♉ R	11^{d} 30′ 43″ ½	9300.1052
Is to the tangent of the greater side R ♈	27 53 42 ½	9723.7546
So is the whole sine ♉ H	90 00 00	10000.0000
To the tangent of H G the measure of the greater angle ♉	69 20 35 ⅓	10423.6494

The angle of the ecliptick and circle of declination as afore.

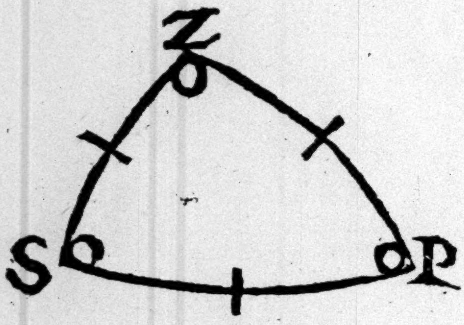
OF OBLIQVE TRIANGLES.

Caſe 1.

By the three ſides, to finde any of the angles.

IN theſe oblique triangles there are 12 Caſes and threeſcore varieties; but becauſe there is little uſe of them in this Treatiſe, and they are already learnedly demonſtrated by Mr. *Henry Gellibrand in Trigonom. Brittannica*; I will only give examples of the Caſes, and leave the ſeverall varieties to every mans private practice.

Let the triangle P Z S repreſent three great circles of the Sphere: P Z part of the meridian of the place between the pole and zenith, P S part of any other meridian between the pole & the Sun, & Z S part of any azimuth between the zenith and the Sunne. And let the three ſides be given, *vizt*. P Z 38 d. 28′ the complement of the latitude, P S 70 d. 0′ the complement of the declination, and Z S 40 d. 0′ the complement of the Sunnes altitude; to finde any of the three angles.



Let the ſide oppoſite to the angle required be alwayes firſt in the operation; and then the rule is. Adde the three ſides together, out of halfe the ſumme ſubtract every ſide, ſo have you the differences; the Arithmeticall complements of the Logarithmes of halfe the ſumme & difference of the baſe added unto the Logarithmes of the difference of the other two ſides, give a number, the halfe whereof is the Logarith. tangent of halfe the angle deſired.

The

The base	*P S*	70 d. 0′		
The sides	*Z S*	40 0		
	Z P	38 28		
The summe		148 28	Logar.	
The halfe sum		74 14	0016.6551	*Arith. compl.*
Diff. of the base		4 14	1131.8354	*Arith. compl.*
Diff. of the sides		34 14	9750.1723	
		35 46	9766.7739	
		Totall	20665.4367	

The halfe 10332.7183 *Is the Logarith. tangent of halfe the angle* 65 d. 4′ 12″ 76

The double is the angle Z 130 d. 8′ 25 52

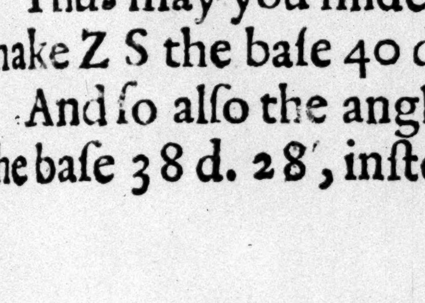
Thus may you finde the angle P to be 31 d. 31′ 43″ 42, if you make Z S the base 40 d. 0′, instead of P S 70 d. 0′.

And so also the angle S to be 30 d. 24′ 6″ 98, if you make P Z the base 38 d. 28′, instead of P S, 70 d. 0.

Case 2.

By the three angles, to finde any of the sides.

IN the same triangle P Z S, let the three angles P, Z, and S be given, to finde the three sides, Z P, Z S, and P S. This case is but the converse of the former, and the sides turned into angles; wherefore let the angle opposite to the side required be alwayes first in the operation, then is the rule the same.



Adde the three angles together, out of halfe the summe of them subtract every angle, so have you the differences; the Arithmeticall complements of the Logarithmes of halfe the summe and difference of the angle opposite to the side required, added unto the Logarithmes of the difference of the other two angles, give a number, the halfe whereof is the Logarith. tangent of halfe the side desired.

The angle opposite S	30^{d}	24′	7″		
The other angles { *P*	31	31	43^{42}		
{ *Z*	49	51	34^{48}	*Compl.*	
The summe	111	47	24^{90}	Logar.	
The halfe summe	55	53	42^{45}	0081.9631 }	*Ar.compl.*
Differ.of the angle S	25	29	35^{45}	0366.1239 }	
Diff of the angle P	24	21	59^{03}	9615.4977	
Diff.of the angle Z	6	2	7^{57}	9021.7911	
			Totall	19085.3758	
			The halfe	9542.6879	*Is the Lo-*

garith. tangent of halfe the side 19^{d} 14′
The double is the whole side P Z 38 28

Thus may you finde the side Z S to bee 40 d. 0′, if you make P the angle opposite to the side sought, 31 d. 31′ 43″ 42 instead of S 30 d. 24′ 7″.

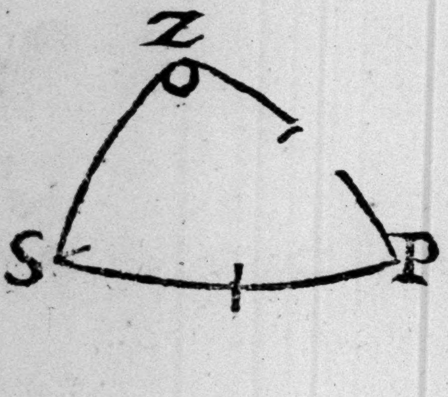
And so also the side P S to be 70 d. 0′, if you make Z the angle opposite to the side sought 130 d. 8′ 25″ 52 instead of S 30d. 24′ 7″.

Note, because 49 d. 51′ 34″ 48 is the complement of the obtuse angle Z to 180 d. therefore the number found is the cotangent of halfe the side S P desired.

Case 3.

By any angle and the two sides opposite to the angle given and sought, to finde the other angles.

IN the same triangle P Z S, let the acute angle S, with the side Z P opposite thereto, and the side P S opposite to the angle sought be given, to finde the obtuse angle Z.



In all sphericall triangles whatsoever, the sines of the sides and sines of the opposite angles are proportionall one to the other, and contrary: *by the 16 and 17 of the 4 book of Regiomont.*

As

				Logar.	
As the sine of the side PZ	38^d 28′	0″		0206.1683	*Ar.com.*
Is to the sine of the angle PSZ	30	24	7	9704.2046	
So is the sine of the side PS	70	0	0	9972.9858	
To the sine of the angle PZS	130	8	$25\frac{1}{2}$	19883.3587	

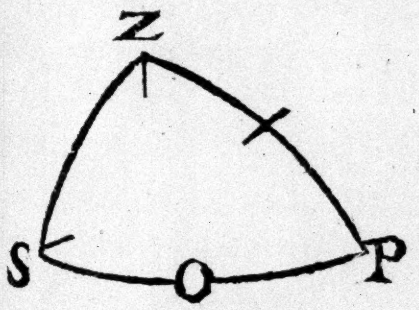
Or 49 d. 51′ 34″ $\frac{1}{2}$, because the same sine serves both for the obtuse and acute angle.

And so of the other angle, giving the side Z S instead of Z P.

Case 4.

By any side and the two angles opposite to the sides given & sought, to finde the other two sides.

IN the same triangle P Z S, let the side P Z and the two angles, S opposite to the side given, and Z opposite to the side sought, be given, to finde the side P S.



This case is but the converse of the former, for in all sphericall triangles the sines of the angles and of their opposite sides are proportionall one to the other, *by the same* 16 *and* 17 *prop. of the* 4 *book of Regiomont.*

				Logar.	
As the sine of the angle PSZ	30^d	24′	7″	0295.7954	*Ar.comp.*
Is to the sine of the opposite side PZ	38	28	0	9793.8317	
So is the sine of the angle PZS	130	8	$25\frac{1}{2}$	9883.3587	*or* 49^d 51′ 34″ $\frac{1}{2}$
To the sine of the opposite side PS	70	0	0	19972.9858	

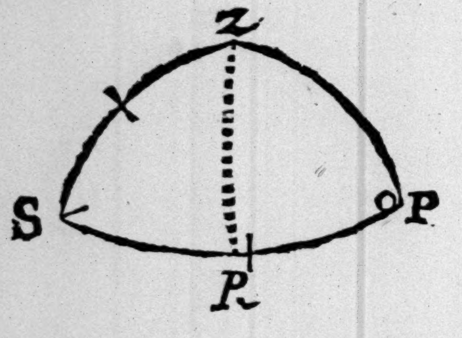
And so may the other side bee also found, giving the angle P instead of Z or S.

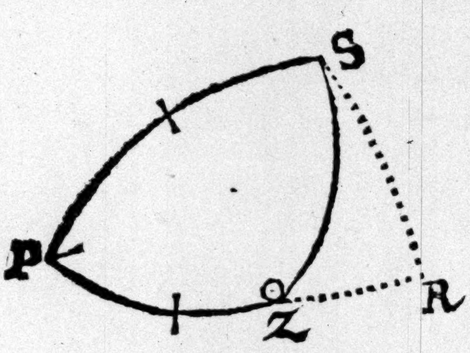
Case 5

Case 5.

By two sides and the angle comprehended, to finde the other angles.

IN the same triangle P Z S, let the greater side P S, and one of the lesser sides Z S, and one of the acute angles S comprehended bee given, to finde the other acute angle P, or obtuse angle Z.





This case and the rest that follow, must bee resolved by help of a perpendicular, which may fall both within and without the triangle, reducing the oblique triangle into two right angled triangles: wherein observe,

1 That if the angles at the base (upon which the perpendicular alwayes fals) be both of one kind, the perpendicular will fall within the triangle, as in the first variety: but if of divers kinds, the perpendicular will fall without the triangle, as in the second variety; and therefore the kinde of the angles at the base must alwayes be known.

2 That in this case the base is one of the sides given adjacent to the angle sought, and the perpendicular must alwayes fall from the extreame of the other side given, upon the base continued, if there be cause.

The proportionals.

As the Radius,
Is to the cosine of the angle given,
So is the tangent of the hypotenusa,
To the tangent of the base between the angle given and the perpendicular.

Secondly,

Secondly,

As the sine of the base between the angle ~~*given*~~ sought *and perpendicular,*
Is to the sine of the base between the angle ~~*sought*~~ given *and perpendicular,*
So is the tangent of the angle given,
To the tangent of the angle sought.

	I	Logar.
As the sine of Z R S	$90^{d}.\ 0'\ 0''$	10000.0000
Is to the cosine of Z S R	30 24 7	9935.7574
So is the tangent of Z S	40 0 0	9923.8135
To the tangent of R S	35 53 $38\frac{1}{2}$	9859.5709
P S	70 0 0	
P R	34 6 $21\frac{1}{2}$	

	Secondly,	Logar.
As the sine P R	$34^{d}.\ 6'\ 21''\frac{1}{2}$	0251.2498 Ar.com.
Is to the sine S R	35 53 $38\frac{1}{2}$	9768.1109
So is the tang. of Z S R	30 24 7	9768.4472
To the tang. of Z P R	31 31 $43\frac{2}{3}$	9787.8079

	II	Logar.
As the sine of P R S	$90^{d}.\ 0'\ 0''$	10000.0000
Is to the cosine of R P S	31 31 $43\frac{2}{3}$	9930.6323
So is the tangent of P S	70 0 0	10438.9341
To the tangent of P R	66 52 38	10369.5664
P Z	38 28 0	
Z R	28 24 38	

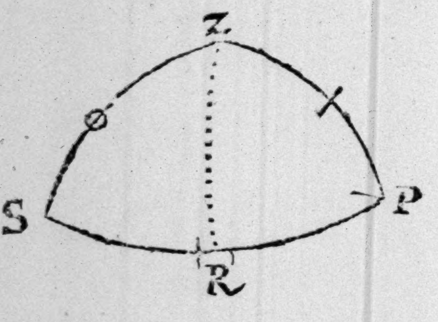
	Secondly,	Logar.
As the sine of Z R	$28^{d}.24'\ 38''$	0322.5882 Ar.com.
Is to the sine of P R	66 52 38	9963.6309
So is the tang. of S P R	31 31 $43\frac{2}{3}$	9787.8079
To the tang. of S Z R	49 51 $34\frac{1}{2}$	10074.0270
Therefore S Z P	130 8 $25\frac{1}{2}$	

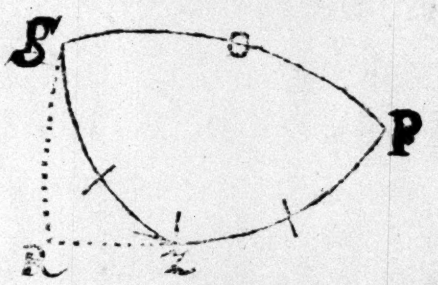
Case

Case 6.

By two sides and the angle comprehended, to finde the other side.

IN the same triangle P Z S, let the greater side P S, and one of the lesser sides P Z, and the acute angle P comprehended bee given, to finde the other side Z S: or let the two lesser sides Z P, and Z S, with the obtuse angle Z comprehended be given, to finde the greater side P S.





In this case also the base is one of the sides given, and the perpendicular must fall from the extream of the other side given, and continued if there be cause; and therefore may fall indifferently, from Z or S in the first variety, and from P or S in the second variety, but whether within or without the triangle, the first of the former cautions will direct you.

The proportionals.

As the Radius,
Is to the cosine of the angle given,
So is the tangent of the hypotenusa,
To the tangent of the base between the side given and the perpendicular.

Secondly,

As the cosine of the base between the side given and perpendicular,
Is to the cosine of the base between the side sought and perpendicular,
So is the cosine of the side given,
To the cosine of the side sought.

As

	I	Logar.
As the sine of Z R P	$90^{d}.\ 0'\ \ 0''$	10000.0000
Is to the cosine of Z P R	$31\ \ 31\ \ 43\frac{2}{5}$	9930.6323
So is the tangent of Z P	38 28 0	9900.0865
To the tangent of R P	$34\ \ 6\ \ 21\frac{1}{2}$	✗9830.7188
P S	70 0 0	
R S	$35\ \ 53\ \ 38\frac{1}{2}$	

	Secondly,	Logar.
As the cosine of P R	$34^{d}.\ 6\ \ 21''\frac{1}{2}$	0081.9687 Ar.com.
Is to the cosine of S R	$35\ \ 53\ \ 38\frac{1}{2}$	9908.5401
So is the cosine of P Z	38 28 0	9893.7452
To the cosine of S Z	40 0 0	✗9884.2540

	II	Logar.
As the sine of Z R S	$90^{d}.\ 0'\ \ 0''$	10000.0000
Is to the cosine of R Z S	$49\ \ 51\ \ 34\frac{1}{2}$	9809.3327
So is the tangent of S Z	40 0 0	99 3.8135
To the tangent of R Z	28 24 38	✗9733.1462
Z P	38 28 0	
R P	66 52 38	

	Secondly,	Logar.
As the cosine of Z R	$28^{d}.24'\ 38''$	0055.7344 Ar.com.
Is to the cosine of P R	66 52 38	9594.0645
So is the cosine of Z S	40 0 0	9884.2539
To the cosine of P S	70 0 0	✗9534.0528

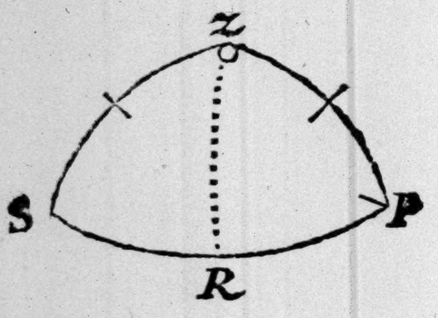
Case 7.

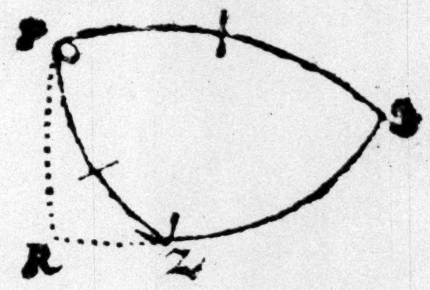
By two sides and an angle adjacent to either, to finde the other angles.

IN the same triangle P Z S, let the two lesser sides Z P and Z S, and the acute angle P adjacent to the side Z P bee given, to finde the obtuse angle Z. Or let the greater side P S, and one of the lesser sides P Z, and the obtuse angle Z adjacent to the side P Z be given, to finde the acute angle P.

In

In this case the base is alwayes the side unknown, and the perpendicular must fall from the angle sought, upon the base continued, if there be cause; but whether within or without the triangle, the caution of the fift case will direct you.





The proportionals.

As the Radius,
Is to the cosine of the side adjacent to the angle given,
So is the tangent of the angle given,
To the cotangent of the angle between the same side and the perpendicular.

Secondly,

As the tangent of the side opposite to the angle given,
Is to the tangent of the other side adjacent,
So is the cosine of the angle last found,
To the cosine of the angle between the side opposite and the perpendicular.

	I			Logar.
As the sine of Z R P	90^d.	0'	0''	10000.0000
Is to the cosine of Z P	38	28	0	9893.7452
So is the tangent of Z P R	31	31	43 $\frac{2}{5}$	9787.8079
To the cotang. of P Z R	64	20	35	19681.5531

	Secondly,			Logar.
As the tangent of Z S	40^d	0'	0''	10076.1864 Ar.com.
Is to the tang. of Z P	38	28	0	9900.0865
So is the cosine of P Z R	64	20	35	9636.4720
To the cosine of S Z R	65	47	51	19612.7449
Therefore S Z P	130	8	26	

As

	II			Logar.
As the sine of S R P	90^d	0′	0″	10000.0000
Is to the cosine of Z P	38	28	0	9893.7452
So is the tangent of R Z P	49	51	34 $\frac{1}{2}$	10074.0258
To the cotangent of R P Z	47	7	26 $\frac{1}{2}$	9967.7710

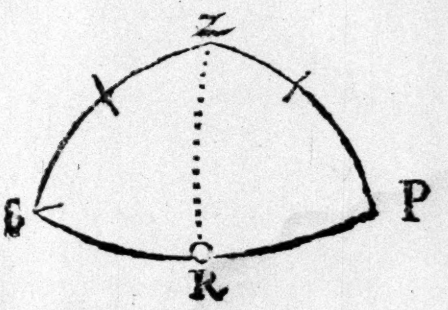
	Secondly,			Logar.
As the tangent of S P	70^d	0′	0″	09561.0658 Ar.com.
Is to the tangent of Z P	38	28	0	9900.0865
So is the cosine of R P Z	47	7	26 $\frac{1}{2}$	9832.7732
To the cosine of S P R	78	39	10	9293.9255
Therefore Z P S	31	31	43 $\frac{2}{3}$	

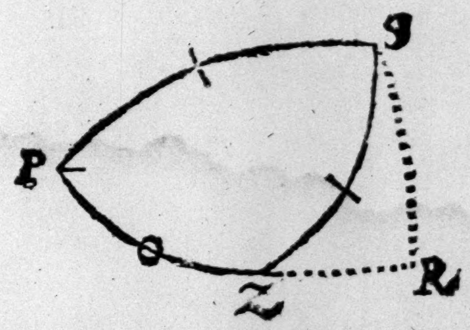
Note that when the perpendicular fals within the triangle, the summe of the verticall angles of the two right angled triangles is the angle sought; when it fals without, the difference of them.

Case 8.

By two sides and an angle adjacent to either, to finde the other side.

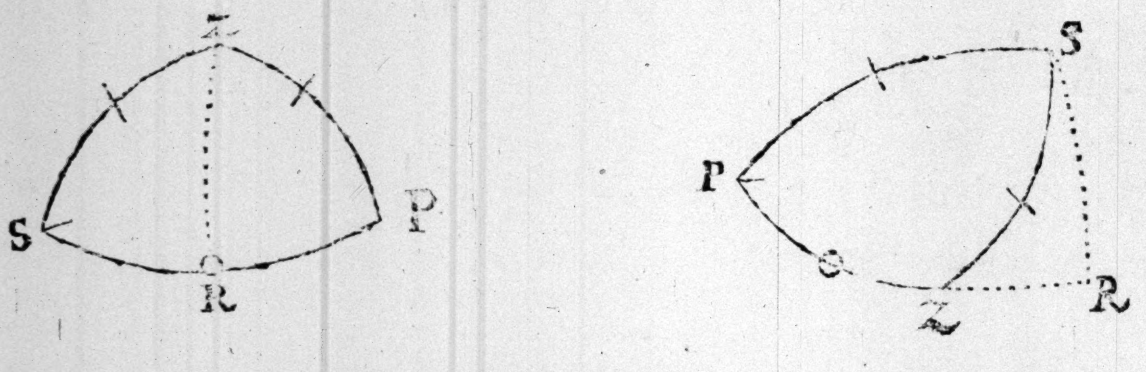
IN the same triangle P Z S, let the two lesser sides P Z and Z *S*, and one of the acute angles *S* adjacent to the side Z *S* bee given, to finde the greater side P *S*. Or let the greater side P *S*, and one of the lesser sides Z *S*, and the acute angle P adjacent to the side P *S* be given, to finde the other side Z P.





In this case the base is alwayes the side sought, and the perpendicular must fall from the opposite angle upon the base continued if there be cause; but whether within or without the triangle, the caution of the fift case will direct you.

The



The proportionals.

As the Radius,
Is to the cosine of the angle given,
So is the tangent of the side adjacent to the angle given,
To the tangent of the base between the perpendicular and the angle given.

Secondly,

As the cosine of the side adjacent to the angle given,
Is to the cosine of the side opposite to the angle given,
So is the cosine of the base between the perpendicular and the angle known.
To the cosine of the base between the perpendicular and the angle unknown.

	I	Logar.
As the sine of Z R S	90^{d}. 0′ 0″	10000.0000
Is to the cosine of Z S R	30 24 7	9935.7574
So is the tangent of Z S	40 0 0	9923.8135
To the tangent of R S	35 53 38½	x9859.5709

	Secondly,	Logar.
As the cosine of Z S	40^{d} 0′ 0′	0115.7461 Ar.com.
Is to the cosine of Z P	38 28 0	9893.7452
So is the cosine of R S	35 53 38½	9908.5401
To the cosine of R P	34 6 21½	x9918.0314
Therefore S P	70 0 0	

As

	II	Logar.
As the sine of P R S	90^d 0′ 0″	10000.0000
Is to the cosine of R P S	31 31 43$\frac{2}{5}$	9930.6323
So is the tangent of P S	70 0 0	10438.9341
To the tangent of P R	66 52 38	10369.5664

	Secondly,	Logar.
As the cosine of P S	70^d 0′ 0″	0465.9484 Ar.com.
Is to the cosine of Z S	40 0 0	9884.2539
So is the cosine of P R	66 52 38	9594.0645
To the cosine of Z R	28 24 38	19944.2668
Therefore Z P	38 28 0	

Note that when the perpendicular fals within the triangle, the summe of the bases of the two right angled triangles, is the side sought; when it fals without, the difference of them.

Case 9.

By two angles and the side comprehended, to finde the other angles.

IN the same triangle P Z S, let the obtuse angle Z, & the acute angle *S*, and the side Z S comprehended bee given, to find the other acute angle P. Or let the two acute angles P and S, with the side P S comprehended be given, to find the obtuse angle Z.

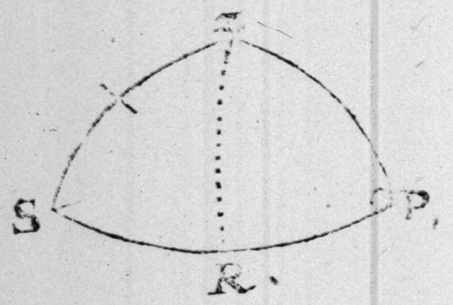
In this case the base may be either of the sides unknown, and the perpendicular must fall from one of the known angles upon the base continued if there be cause: and therfore may fall indifferently from Z or S in the first variety; and from P or S in the second variety; but whether within the triangle, or without, the caution of the fift case will direct you.

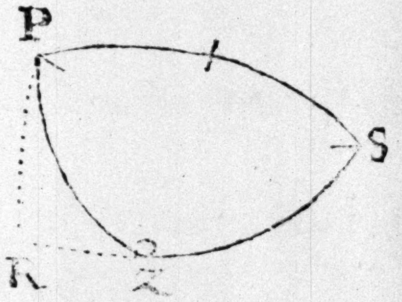
The proportionals.

As the Radius,
Is to the cosine of the side comprehended,
So is the tangent of the angle at the base,
To the cotangent of the angle between the perpendicular and side given.

Secondly,

As the sine of the angle between the perpendicular and side known,
Is to the sine of the angle between the perpend. and sine unknown,
So is the cosine of the angle at the base,
To the cosine of the angle desired.





	I	Logar.
As the sine of Z R S	90^{d} 0′ 0″	10000.0000
Is to the cosine of Z S	40 0 0	9884.2539
So is the tangent of Z S R	30 24 7	9768.4472
To the cotangent of S Z R	65 47 51	x9652.7011
S Z P	130 8 26	
R Z P	64 20 35	

	Secondly,	Logar.
As the sine of R Z S	65^{d} 47 51″	0039.9565 Ar.com.
Is to the sine of R Z P	64 20 35	9954.9188
So is the cosine of Z S R	30 24 7	9935.7574
To the cosine of Z P R	31 31 43 $\frac{2}{3}$	x9930.6327

	II	Logar.
As the sine of P R S	90^{d} 0′ 0″	10000.0000
Is to the cosine of P S	70 0 0	9534.0516
So is the tangent of P S Z	30 24 7	9768.4472
To the cotangent of S P R	78 39 10	x9302.4988
Z P S	31 31 43 $\frac{2}{3}$	
Z P R	47 7 26	

Secondly,

Secondly,

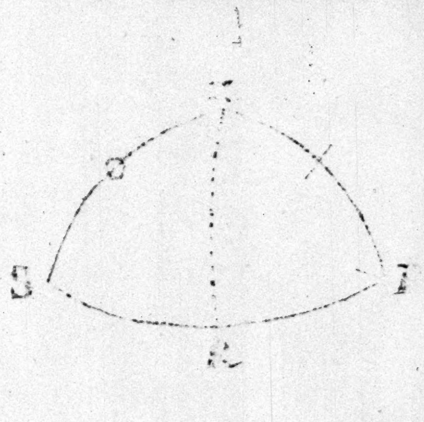
As the sine of S P R	78^{d}	$39'$	$10''$	0008.5733	Ar.com.
Is to the sine of Z P R	47	7	$26\frac{3}{5}$	9865.0022	
So is the cosine of R S P	30	24	7	9935.7574	
To the cosine of R Z S	49	51	$34\frac{1}{2}$	19809.3329	
Therefore P Z S	130	8	$25\frac{1}{2}$		

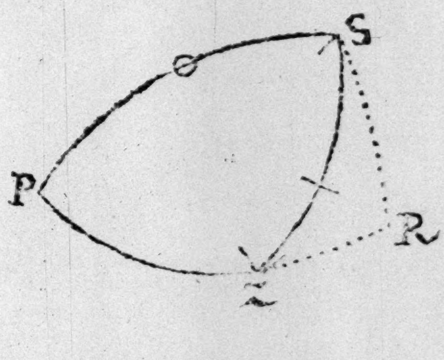
Case 10.

By two angles and the side comprehended, to finde the other sides.

IN the same triangle P Z S, let the obtuse angle Z, and the acute angle P, with the lesser side Z P comprehended be given, to finde the other lesser side Z S. Or let the obtuse angle Z, and the acute angle S, with the lesser side Z S comprehended be given, to finde the greater side P S.

In this case the base is alwayes the third side, neither given nor sought, and the perpendicular must fall from the angle given adjacent to the side sought upon the base continued if there be cause, but whether within the triangle or without, the caution of the fift case will direct you.





The proportionals.

As the Radius,
Is to the cosine of the side given,
So is the tangent of the angle at the base,
To the cotangent of the angle between the perpendicular and the side given.

 Secondly,

Secondly,

As the cosine of the angle between the perpendicular and side sought,
Is to the cosine of the angle between the perpendicular and side given,
So is the tangent of the side given,
To the tangent of the side sought.

I

		Logar.
As the sine of Z R P	90d 0′ 0″	10000.0000
Is to the cosine of Z P	38 28 0	9893.7452
So is the tangent of Z P R	31 31 43 2/3	9787.8079
To the cotangent of P Z R	64 20 35	19681.5531
P Z S	130 8 25 1/2	
R Z S	65 47 50 1/2	

	Secondly,	Logar.
As the cosine of S Z R	65d 47′ 50″ 1/2	0387.2551 Ar.com.
Is to the cosine of P Z R	64 20 35	9636.4720
So is the tangent of Z P	38 28 0	9900.0865
To the tangent of Z S	40 0 0	19923.8136

II

		Logar.
As the sine of P R S	90d. 0′ 0″	10000.0000
Is to the cosine of Z S	40 0 0	9884.2539
So is the tangent of S Z R	49 51 34 1/2	10074.0258
To the cotangent of Z S R	47 44 52	19958.2797
Z S P	30 24 7	
R S P	78 8 59	

	Secondly,	Logar.
As the cosine of P S R	78 . 8 59″	0687.4961 Ar.com.
Is to the cosine of Z S R	47 44 52	9827.6244
So is the tangent of Z S	40 0 0	9922.8135
To the tangent of P S	70 0 0	10438.9340

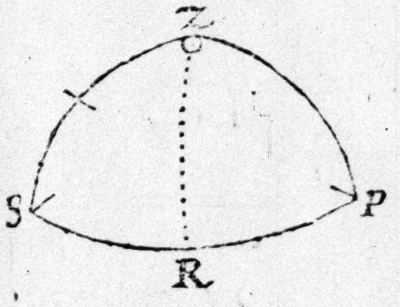
Case II.

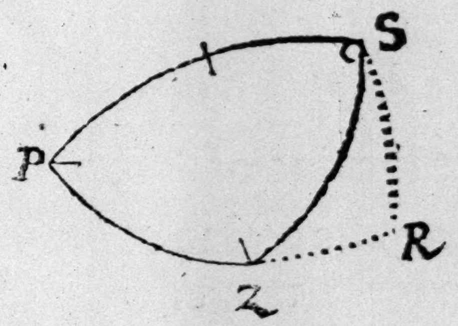
Case II.

By two angles and the side adjacent to either, to finde the other angle.

IN the same triangle P Z S, let the two acute angles P and S, and the side Z S adjacent to the angle S be given, to finde the obtuse angle Z. Or let the obtuse angle Z, and one of the acute angles P, with the side P S adjacent to the angle P be given, to finde the acute angle S.

In this case the base is alwayes opposite to the angle sought, and the perpendicular must fall from the angle sought upon the base continued if there be cause; but whether within the triangle, or without, the caution of the fift case will direct you.





The proportionals.

As the Radius,
Is to the cosine of the side given,
So is the tangent of the angle adjacent to the side given,
To the cotangent of the angle comprehended by the perpendicular and the side given.

Secondly,

As the cosine of the angle adjacent to the side given,
Is to the cosine of the other angle given,
So is the sine of the angle comprehended by the perpendicular and side known,
To the sine of the angle comprehended by the perpendicular and side unknown.

I

		Logar.
As the sine of Z R S	90^{d}. 0$'$ 0$''$	10000.0000
Is to the cosine of Z S	40 0 0	9884.2539
So is the tangent of Z S R	30 24 7	9768.4472
To the tangent of S Z R	65 47 51	x9652.7011

Secondly,

		Logar.
As the cosine of Z S R	30^{d}.24$'$ 7$''$	0064.2426 Ar.com
Is to the cosine of Z P R	31 31 43$\frac{2}{5}$	9930.6323
So is the sine of R Z S	65 47 51	9960.0435
To the sine of R Z P	64 20 35	x9954.9184
Therefore S Z P	130 8 26	

II.

		Logar.
As the sine of P R S	90^{d} 0$'$ 0$''$	10000.0000
Is to the cosine of P S	70 0 0	9534.0516
So is the tangent of S P R	31 31 43$\frac{2}{5}$	9787.8079
To the cotangent of P S R	78 8 59	x9321.8595

Secondly,

		Logar.
As the cosine of R P S	31^{d} 31$'$ 43$\frac{2}{5}$	0069.3677 Ar.com
Is to the cosine of R Z S	49 51 34$\frac{1}{2}$	9809.3327
So is the sine of P S R	78 8 59	9990.6444
To the sine of Z S R	47 44 52	x9869.3448
Therefore Z S P	30 24 7	

Note, that when the perpendicular fals within the triangle, the summe of the verticall angles of the two right angled triangles, is the angle sought, but when it fals without, the difference of them.

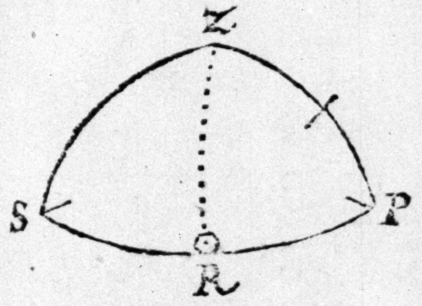
Case 12.

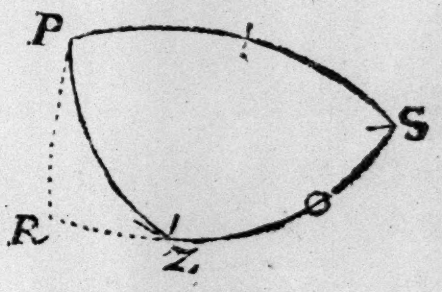
Case 12.

By two angles and the side adjacent to either, to finde the other sides.

IN the same triangle P Z S, let the two acute angles P and S, with the side Z P adjacent to the angle P bee given, to finde the greater side P S. Or let the obtuse angle Z, and one of the acute angles S, with the side P S adjacent to the angle S bee given, to finde the lesser side Z S.

In this case the base is awayes the side sought, and the perpendicular must fall from the angle oppsite to the side sought upon the base continued if there bee cause; but whether within the triangle, or without, the caution of the fift case will direct you.





The proportionals.

As the Radius,
Is to the cosine of the angle adjacent to the side given,
So is the tangent of the side given,
To the tangent of the base between the perpendicular and the side given.

Secondly,

As the tangent of the angle opposite to the side given,
Is to the tangent of the angle adjacent to the side given,
So is the sine of the base between the perpendicular and side known,
To the sine of the base between the perpendicular and side unknown.

As

I

					Logar.
As the sine of Z R P	90^d.	0$'$	0$''$	10000.0000	
Is to the cosine of Z P R	31	31	43 $\frac{2}{5}$	9930.6323	
So is the tangent of Z P	38	28	0	9900.0865	
To the tangent of R P	34	6	21 $\frac{1}{2}$	9830.7188	

Secondly,

				Logar.	
As the tangent of Z S P	30^d	24$'$	7$''$	10231.5527	Ar.com.
Is to the tang. of Z P R	31	31	43 $\frac{2}{5}$	9787.8079	
So is the sine of P R	34	6	21 $\frac{1}{2}$	9748.7501	
To the sine of S R	35	53	38 $\frac{1}{2}$	9768.1107	
Therefore P S	70	0	0		

II

				Logar.
As the sine of P R S	90^d	0$'$	0$''$	10000.0000
Is to the cosine of P S R	30	24	7	9935.7574
So is the tangent of P S	70	0	0	10438 9341
To the tangent of R S	67	7	13 $\frac{2}{5}$	10374.6915

Secondly,

				Logar.	
As the tangent of R Z P	49^d	51$'$	34$''$ $\frac{1}{2}$	9925.9742	Ar.com.
Is to the tang. of R S P	30	24	7	9768.4472	
So is the sine of S R	67	7	13 $\frac{2}{5}$	9964.4123	
To the sine of Z R	27	7	13 $\frac{2}{5}$	9658.8337	
Therefore Z S	40	0	0		

Note that when the perpendicular fals within the triangle, the summe of the bases of the two right angled triangles is the side sought; but when it fals without, the diffence of them.

CHAP. IV.

The explanation and making of the fundamentall Scheme.

THis Scheme representeth to the eye the true and naturall situation of those circles of the Sphere, whereof wee shall have use in the description of such sorts of Dials, as any flat or plane is capable of: It is therefore necessary, first to explane the same, and the making thereof, that the Symetry of the Scheme with the Globe being well understood, the representation of every plane therein may bee the better conceived.

Suppose therefore, that the Globe elevated to the heighth of the Pole, bee pressed flat downe into the plane of the Horizon, then will the outward circle or limbe of this Scheme N E S W represent that Horizon, and all the circles contained in the upper Hemisphere of the Globe may be artificially contrived and represented thereon, as are Azimuthes, Almicanters, Meridians, Paralels, Equator, Ecliptick, Tropicks, and circles of Position, &c. which are thus distinguished in the Diagram.

Let Z be the Zenith of the place, and center of the horizontall circle N E S W, let N Z S be the Meridian, P the Pole of the world, elevated above the north part of the Horizon N, here at *London*, 51 d. 32′, the complement whereof is P Z 38 d. 28′, the distance between the Pole and the Zenith, E Z W the prime verticall, D Z G and C Z V any other intermediate Azimuthes, NOS a circle of Position, E K W the Equator, the distance whereof from Z is equall to P N the heigth of the Pole, or from S equall to P Z the complement thereof, *n* B Q *r* the Tropick or paralell of ♋, *p* F *t* the Tropick of ♑, and B R Q an Almicanter, or paralell to the Horizon: The rest of the circles intersecting each other in the point P are the Meridians or houre-circles cutting the horizon and other circles of this Diagram so in the Scheme, as they do in the Globe it selfe.

Amongst these, the Azimuthes only in this projection become streight lines, all the rest remaine circles, and are greater

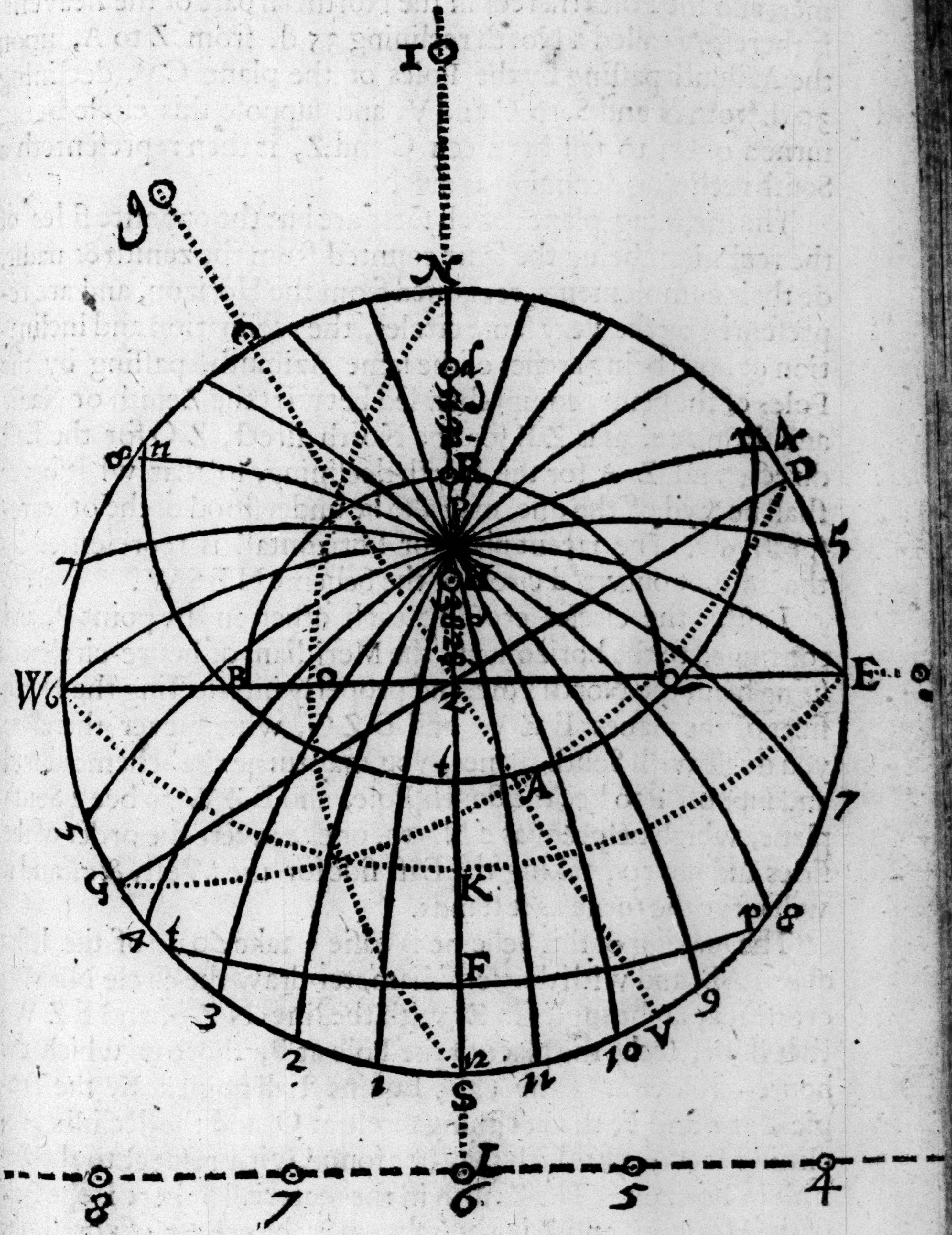
or lesser according to their naturall situation in the Globe. By the streight lines are represented all erect planes, whether direct or declining; by the great circles, all the rest, both jacent, reclining, and declining reclining, which for more plainnesse sake, may thus particularly be described.

E Z W the prime verticall, or Azimuth of East and West, representeth all South and North planes, which are perpendicular to the Horizon, and crosse the Meridian at right angles; N Z S the Meridian or Azimuth of South and North, representeth all East and West planes, which are perpendicular to the Horizon, as the former, and cut the prime verticall at right angles; D Z G an Azimuth lying between these cardinall points, representeth any declining plane, which is also perpendicular to the Horizon, but cutteth the Meridian at oblique angles, from whence the Poles and axis of the plane C Z V deviateth as much as the plane it selfe D Z G declineth from the prime verticall; and these be all the varieties of erect planes.

There are furthermore three sorts of reclining and inclining planes, and they are either North and South reclining, or East and West reclining, or declining reclining.

The first sort is represented by the Equator, or prickt circle E K W, which cutteth the Meridian at right angles, but reclineth from the Zenith 51 ^{d}. 32′, equall to the latitude of the place, and lying open to the North, and the Poles thereof in the North part of the Meridian, is therefore called a North reclining 51 ^{d}. 32′ from Z to K, and suppose this circle being turned over, to fall between N and Z, it then representeth a South reclining as much. The second sort is represented by the circle of position, or prickt circle N O S, which cutteth the prime verticall at right angles, but reclineth from the Zenith 40 ^{d}. and lying open to the Sunne-rise, and the Poles thereof in the East part of the prime verticall, is therefore called an East reclining 40 ^{d}. from Z to O, and suppose this circle being turned over, to fall between Z and E, it then representeth a West reclining as much.

The third sort is represented by the prickt circle D A G, which cutting C Z V the Azimuth and axis of the plane D Z G at right angles in A, is oblique to all the rest of the circles, but reclineth from



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from the Zenith 35 d. and lying open to the North as the former, and the Pole thereof in the Northern part of the heavens is therefore called a North reclining 35 d. from Z to A, upon the Azimuth passing by the Poles of the plane CV, declining 30 d. from N and S, to C and V, and suppose this circle being turned over, to fall between C and Z, it then representeth a South reclining declining as much.

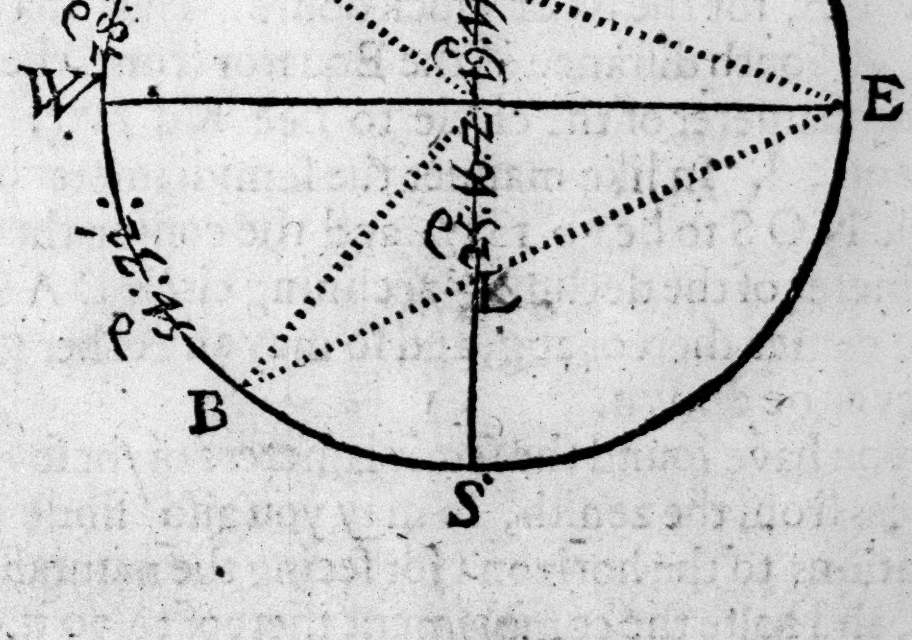
The inclining planes of all sorts are but the opposite sides of the reclining, being the same counted from the zenith & nadir, or their complements, reckoned from the Horizon, and are represented by the very same circles, the reclination and inclination of both being arches of the same Azimuth, passing by the Poles of the plane, comprehended betwixt the Zenith or Nadir and the plane, as is Z K for the North direct, Z O for the East direct, and Z A for the North declining, so that whatsoever shall be sayd of the one, may also be understood of the other respectively. The jacent plane or horizontall is represented by the limb or outward circle of the Scheme N E S W.

Lastly, the circles crossing each other in the point P, and continued to the horizon, are the Meridians or houre-circles, issuing from the North Pole, and properly intersecting the North sides of the planes E Z W and D Z G, whensoever therefore you deale with South planes, you may turne the Scheme about, and suppose P to bee the South Pole, and E Z W to bee a South plane, which before was a North, or else invert the order of the sides and houres, taking the East side for the West, &c. and it will serve the turne as it stands.

The making of this Scheme is easie; take 60 d. of the lesser chord AB, and with that semidiameter draw the circle NESW; crosse it at right angles in Z, with the lines N Z S, and E Z W; that done, seeke the place of the Pole at P, thorow which the houre-circles must passe; the Equinoctiall point at K, the Tropicks at *t* and F, the reclining circle at O, and the declining reclining at A; all which may bee found with respect to the Zenith or horizon. The Zenith in the materiall Sphere is the Pole of the Horizon, and Z in the Scheme is the center of the limbe representing the same, from which point the distance of each circle being given both wayes, as it lyeth in the sphere, and set

upon

upon the azimuth, or streight line of the Schem proper thereunto, you may by helpe of the naturall tangents of halfe their arches give three points to draw each circle by ; but if the naturall tangents of both distances from the Zenith bee added together, the halfe thereof shall bee the semidiameters of those circles desired. The reason why the naturall tangents of halfe the arches are here taken, which seldome come in use, may bee made plaine by this diagram, wherein making E Z the radius, S Z N is a tangent line thereunto, upon which if you will project the whole semicircle S W N, it is manifest by the worke, that every part of the lines Z N, or Z S, can bee no more but the tangent of halfe the arch desired, because the whole line Z N, or Z S, being the tangent of 45 d. but halfe of the quadrant is equall to the Radius Z E the sine of the whole quadrant: but a further reason may be given out of the 53 of the 1 of *Pitiscus*, or the 20 of the 3 bo. of *Euclid*, where it is proved, that all angles in the circumference are but halfe the angles in the center, and therefore W E A but halfe the angle of W Z A, and W E B but halfe of W Z B ; if then E Z of the fundamentall Schem bee Radius 1000, Z P shall bee 349 the naturall tangent of 19 d. 14′ the



halfe of 38 d. 28′, the distance between the North Pole and the Zenith, in our latitude of 51 d. 32′; and Z K shall be 483 the naturall tangent of 25 d. 46′ the halfe of 51 d. 32′ the distance between the Zenith and Equinoctiall, equall to the heigth of the Pole; in like manner Z *t* will be 249 the naturall tangent of 14 d. 0′ ½, Z F will be 765 the naturall tangent of 37 d. 26′, Z O will be 364, the naturall tangent of 20 d. 0′, and Z A 315 the naturall tangent of 17 d. 30′ halfe the arch of each circles distance from the Zenith. Having found these points on the one side of the Zenith, you must seeke the opposites to them on the other side also, which in all great circles, as are E P W, E K W, S O N, and D A G, are the complements of the former to 90 d. wherefore the distance between the Zenith and the North Pole being 349 the naturall tangent of 19 d. 14′ halfe the arch of 38 d. 28′, the distance between the zenith and the South Pole shall bee 2866, the naturall tangent of 70 d. 46′, the complement of the former; halfe the arch between the zenith and South Pole Z S, being 90 d. and the South Pole 51 d. 32′ under the horizon, adde these two tangents together, and you have the whole diameter of that circle 3215 the halfe whereof is 1607, that is one radius and neere 61 hundred parts of another, is the semidiameter or distance of the center L from the Pole P, to which width open the compasses, and set off the distance P L either by help of the line A 10, B 10, equall to the radius Z E, divided by diagonall lines into 100 parts, (as in the 1 Chapt.) or by the help of a sector, opened to the width of Z E, and therewith draw the circle W P E, for the six of clock houre. Thus may you by the North and South distance of the Equator from the zenith, finde the semidiameter of the circle to bee K d 1277, and the center thereof at d. In like manner the semidiameter of the reclining circle N O S to be f o 1555, and the center thereof at f, the semidiameter of the declining reclining circle D A G, to be A g, and the center thereof at g, and so may any other great circle whatsoever be drawn.

Now as you have found the semidiameters of these circles by their distances from the zenith, so may you also finde them by their inclinations to the horizon: for seeing the naturall tangent of any arch, and halfe the complement thereof to 90 d. is evermore

more equall both to the secant of the said arch, and also to the semidiameter of the circle desired, by the 30 of 5 b. of *Finkius*, *Geom. Rotondi*, you may easily prepare a table, (as in this example) wherein the secants themselves of each circles inclination to the horizon, are the semidiameters sought for; so shall 1607 the secant of 51 d. 32′, the inclination of the six of clock houre-circle to the horizon, be the semidiameter LP, by which to draw that circle W P E, and 1277 the secant of 38 d. 28′, the inclination of the Equator to the horizon, shall bee the semidiameter d K, by which to draw the circle W K E, and so of all great circles, but not of the smaller.

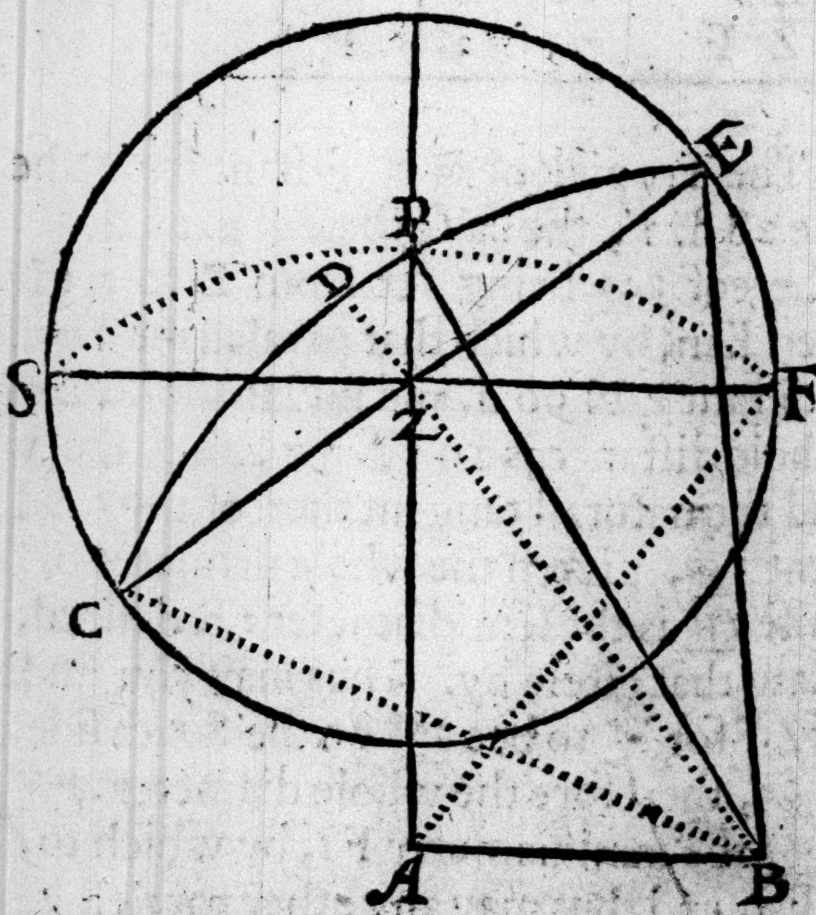
Reclinate from the zenith.	The arches.	Inclinate to the horizon.	The arches.	Their Secants.	The semidiameters.
Z P	38d. 28	P N	51d. 32′	1607	L P
Z K	51 32	K S	38 28	1277	d K
Z O	40 0	O W	50 0	1555	f O
Z A	35 0	A V	55 0	1743	A g
Z *t*	28 1	*t* S	61 59	2129	*t* R
Z F	75 3	F S	14 57	1035	F I

The Tropick of ♋ is distant from the zenith on the South side 28 d. 1′, the halfe thereof is 14 d. 0′ ½, the naturall tangent whereof 249 being set from Z to *t*, giveth the point *t* in the Meridian, by which that paralell must passe; on the North side it is distant Z N 90 d. and under the horizon 14 d. 57′ more, the whole distance is 104 d. 57′, the halfe whereof is 52 d. 29′ ½, and the naturall tangent thereof 1302, added to the former tangent 249, giveth the whole diameter of that circle 1551, whose halfe 776 is the semidiameter *t* R desired, and R the center to draw that circle by. Thus may you finde the naturall tangent of Z F for ♑ to bee 768 on the South side, and on the North side 4006, therefore the whole diameter 4768, and the halfe thereof 2384 the semidiameter F I, by which to draw the Tropick of ♑ *p* F 4, and thus may any other paralell be likewise drawn. The circle B R Q representeth an almicanter of 35 d. above the horizon,

rizon, therefore 55 d. from the zenith, whose halfe is 27 d. 30', and the naturall tangent thereof 520, which taken of the sector, or line divided as aforesaid, giveth the length of Z B, or Z Q the semidiameter of the almicanter desired. The streight lines C Z A, or D Z G, are put upon the limb, by help of the chord, 30 d. distant from the cardinall points N E S W, and must crosse each other at right angles in Z, representing two azimuthes equidistant from the Meridian and prime verticall.

Last of all, the houre-circles are thus to be drawn; first seek the center of the six of clock houre circle as formerly directed, whose distance from P or E will alwayes bee the secant of the heigth of the Pole, making Z E the radius, and is found at L upon the meridian line continued by setting the secant of 51 d. 32' from P to L, which crosse at right angles in L, with the line 8 L 4, extended farre enough to serve the turne; make P L the radius, then shall 8 L 4 be a tangent line thereunto, and the naturall tangents of the Equinoctiall houre arches, *vizt.* of 268 for 15 d. of 577 for 30 d, of 1000 for 45 d, of 1732 for 60, and of 3732 for 75 d, set both wayes from L to 5 and 7, 4 and 8, &c.

This Demonstration I received from my worthy friend, the famous Mathematician of our time, Mr. Henry Briggs.



give

give the true centers of thoſe houre circles, and the ſecants of 1035 for 15 d, of 1155 for 30 d, and of 1414 for 45 d, &c. equall to 5 P, 4 P, &c. ſhall bee the ſemidiameters of the houre circles deſired, as by this demonſtration may appeare. Let the inſtance be in the ſecond houre from ſix C D P E, whoſe center will bee found two houres diſtant from 12, make P A the radius, then ſhall A B be a tangent line thereunto, and 577 the naturall tangent of 30 d. ſet from the point A, ſhall give the center at B, and B P 1155 the ſecant of 30 d. ſhall be the ſemidiameter of the circle C D P E. To prove this, the center muſt of neceſſity be in the line D Z B, becauſe it is perpendicular to the ſubtenſe of that houre circle C Z E, ſuppoſe in B, then muſt B C, B P, and B E be equall, which cannot be denied, if their ſquares bee equall, but the ſquare of B E is equall to the ſquares of E Z, Z A, and A B, and the ſquare of B P is equall to the ſquares of F Z, Z A, and A B, becauſe A F, and A P, are equall: laſtly, Z E, and Z F, are alſo equall, therefore the ſquares of B E, and B P, and by the ſame reaſon of B C, which was to be proved, and conſequently the point B the true center, and B P the ſemidiameter, by which to draw the periphery C D P E, the houre deſired. The ſchem, the lines, and circles thereof, being thus made plaine, we now come to the Art of Dialling it ſelfe, which is firſt contracted into a few generall rules, and then the particulars handled at large.

CHAP. V.

An abſtract of the Art of Dyalling, by which briefe view of the ſeverall Planes, and what is requiſite in every of them, the reſt of the work is better underſtood, and more eaſily performed.

ALL great circles of the Sphere projected upon any plane howſoever ſituated, become ſtreight lines, which are the common ſections of the circles and the plane, (as *Clavius* in the 11 of his firſt booke of *Gnomonices* demonſtrateth) from whence it followeth, that the houre lines of every Dyall, (being great circles of the Sphere) drawn upon

any

any plane superficies, must therefore be streight lines also.

Now the Art of Dialling consisteth in the artificiall finding out of these lines, and their distances each from other, which continually vary, according to the situation of the plane, on which they are projected.

Of these planes there are but 3 sorts, the

- 1, Paralell to the horizon, as is the horizontall only.
- 2, Perpendicular to the horizon, as are all erect planes, which either be
  - Direct, as
    - North and South, and
    - East and West.
  - Or declining.
- 3, Inclining to the horizon, or rather reclining from the zenith, which are either
  - Direct planes, as
    - Reclining and inclining. North and South.
    - and
    - Reclining and inclining. East and West.
  - Or declining reclining and inclining planes.

To contrive the houre lines upon these severall planes, there are certain sphericall arches, and angles of great circles, in number six, which must of necessity bee known, and divers of these are in some Cases given, in others they are sought.

1 The first is an arch of the horizon betwixt the meridian and azimuth, passing by the poles of the plane, which is the declination, as S D, or N C, in the Schemes, Chap. 15. 17, 18, &c.

2 The second is an arch of a great circle, perpendicular to the plane, comprehended betwixt the zenith and the plane, which is the reclination, as Z H, Z G, and Z E, in the greater Scheme, Chap. 15, and these two are usually given, so oft as they come in question, or may be found by the rules of the 10 Chap.

3 The third is an arch of the plane, betwixt the meridian and the horizon, prescribing the distance of the 12 of clock houre

from

from the horizontall line, as P B, and O B, in the lesser Schemes, Chap. 15, and 16.

4 The fourth is an arch of the plane, betwixt the meridian and the substile, which limits the distance thereof from the 12 of clock houre line, as O R in the smaller Schemes of the 16, 17 and 19 Chap. aforesaid.

5 The fift is an arch of the great circle, perpendicular to the plane, comprehended betwixt the pole of the world, and the plane commonly called the heigth of the stile, as P R in the sayd Schemes.

6 The last is an angle at the pole, betwixt the two meridians, the one of the place, the other of the plane, (taking the substile in the common sense for the meridian of the plane) as is R P O, in the diagrams of the Chap. 16 and 17.

First sort horizontall.

In the first sort of these planes, there is nothing required, but the arch of the meridian, betwixt the pole and the plane, which is the heigth of the pole it selfe above the horizon, and is alwayes given, as P N in the Schem, Chap. 6.

Second sort East and West.

In the second sort of planes, the direct East and West have no pole elevated, nor any of these arches necessarily required, but the houre lines being paralels, are contracted, and enlarged from the length of the stile.

North and South.

In the North and South planes, the arch of the meridian betwixt the pole and the plane, is the complement of the former, betwixt the pole and the horizon, which is therefore given, as *P Z* in the former Schem of the 6 Chap. and the arch of the horizon, betwixt the meridian and the plane, is awayes 90 d. as N W, or S E, in the Schem aforesaid.

Decliners.

But in erect decliners, three things are to be sought, besides the arch of the horizon, betwixt the meridian and the poles of the plane, which is the declination, and is usually given.

1 The first is the arch of the great circle betwixt the pole of the world and the plane, commonly called the heigth of the stile,

ſtile, as P R in the ſchem, Chap. 10, and is thus found.

As the whole ſine Z S in the ſame ſchem,
Is to the coſine of the declination S G,
So is the coſine of the elevation Z P.
To the ſine of the heigth of the ſtile P R, by the 1 of the 1 caſe of R. S. Triangles.

2 The ſecond is the arch of the plane betwixt the meridian and the ſubſtile, as *Z R* in the ſame ſchem.

As the cotangent of the declination S G,
Is to the tangent of the heigth of the ſtile P R,
So is the whole ſine G Z,
To the ſine of the arch of the plane R Z, the diſtance of the meridian and ſubſtile, by the ſecond of the fourth caſe of R. S. Triangles.

3 The third is the angle betwixt the two meridians, the one of the place, the other of the plane, as Z *P R* in the ſame ſchem.

As the coſine of the elevation P Z,
Is to the ſine of 90 d. P R Z,
So is the ſine of the arch of the plane betwixt the ſubſtile and meridian R Z,
To the ſine of the angle at the pole betwixt the two meridians Z P R, by the ſecond of the fifteenth caſe of R. S. Triangles.

Third ſort.

In the third ſort of planes, the direct reclining North and South, have the arch of the horizon betwixt the meridian and the plane, and the arch of the plane betwixt the meridian and horizon, alwayes 90 d. as is S E, or N W, and A E, or B W in the ſchem Chap. 13. and the inclination of the plane to the horizon N E A, or the reclination thereof from the zenith *Z* E A is uſually given, only the arch of the meridian betwixt the pole and the plane is ſought for.

South recliners.

The ſame in South recliners is found by ſubtracting the reclination out of the complement of the elevation, when it is leſſe, (as *Z C* out of *Z P*,) or the complement of the elevation out of it, (as *Z P* out of *Z A*,) when it reclines more than the pole.

North

North recliners.

But in North recliners how farre soever, adde the complement of the elevation to the reclination, (as *P Z* to *Z F*) the aggregate under 90 d. or the complement thereof to 180 d. above 90 d. is the heigth of the pole desired.

East and West reclining.

In direct reclining East and West, the arch of the horizon betwixt the meridian and the plane, is alwayes 180 d. as is S W N, or N E S in the schem Chap. 12. and the angle of inclination of the plane to the horizon W N O, or the reclination thereof from the zenith, which is an arch of the prime verticall Z O, is usually given, therefore we seeke,

1 The arch of the great circle, betwixt the pole of the world and the plane, which is the heigth of the stile P R in the schem aforesayd.

As the whole sine N Z,
Is to the sine of the elevation N P,
So is the sine of the reclination Z O,
To the sine of the heigth of the stile P R, by the first of the first case of R. S. *Triangles.*

2 The arch of the plane betwixt the meridian and the substile, as is N R in the schem aforesayd.

As the tangent of the reclination ZO,
Is to the tangent of the heigth of the stile P R,
So is the whole sine O N,
To the sine of the arch of the distance of the substile from the meridian R N, by the second of the fourth case of R S. *Triangles.*

3 The angle betwixt the two meridians, which is R P N in the said schem.

As the sine of the arch of the meridian betwixt the pole and the horizon P N,
Is to the sine of 90 d. P R N,
So is the sine of the arch of the plane betwixt the substile and the meridian R N,
To the sine of the angle at the pole betwixt the two meridians R P N, by the second of the fifteenth case of R. S. *Triangles.*

Declining reclining.

In declining reclining planes let the arch of the horizon betwixt

twixt the meridian and the poles of the plane, S D and N C, or N D and S C which is the declination, and the arch of the great circle, perpendicular to the plane, betwixt the zenith and the plane *Z G*, *Z H*, or *Z F*, which is the reclination, (as in the smaller schemes, Chap. 15, 16, and 17.) bee alwayes given, then must the other arches and angle be sought.

1 The arch of the plane betwixt the meridian and horizon P B, and O B, in the schemes aforesaid, and *A a*, and *A O*, in the smaller schemes, Chap. 18, 19, 20.

As the whole sine Z C in the South, and Z D in the North decliners,

Is to the tangent of the declination C S, or C N in South, and D S in North,

So is the sine of the reclination Z G, Z H, or Z F in both,

To the tangent of G P and G a, H O or F O in both, whose complements P B and O B, A a and A O are the arches desired, by the first of the fift case of R. S. *Triangles.*

Polar decliners, and Equinoctiall decliners.

2 The arch of the meridian betwixt the zenith and the plane, which in polar decliners (whose planes passe by the intersection of the equator and meridian) is equall to the heigth of the pole, and in equinoctiall decliners (whose planes passe by the poles of the world) is the complement thereof, as is *Z a* Chap. 18, and *Z P* in the lesser schem Chap. 15, in all the rest it is thus found.

As the cosine of the declination S *B and N B in the South, or A S in the North decliners,*

Is to the sine of the arch of the plane betwixt the meridian and horizon O B or A O in both,

So is the sine of the reclination Z H or Z F in both,

To the sine of the arch of the meridian betwixt the zenith and the plane Z O in both, by the fifteenth of the fourth of Regiomont. *or the second of the fourteenth of* Finkius.

Adde Z O to Z P in North decliners, and take Z O out of Z P, or Z P out of Z O (when there is cause) in South decliners, and there remaines P O in them all, the arch of the meridian betwixt the pole of the world and the plane.

3 The arch of the great circle betwixt the pole and the plane

commonly called the heigth of the stile, as is P R in the former schemes, which in equinoctiall decliners is paralell to the axis, in the rest is thus found.

As the sine of the arch of the plane betwixt the meridian and horizon O B in the South, and A a and A O in North decliners,
Is to the cosine of the declination B N and B S in South, or A S in North decliners,
So is the sine of the arch of the meridian betwixt the pole and the plane O P, and a P in both,
To the sine of the heigth of the stile P R in both, by the fifteenth of the fourth booke of Regiomont. *or the second of the fourteenth of* Finkius.

4 The arch of the plane betwixt the meridian and the substile, as O R and æ R in the former schemes, which in polar decliners is alwayes 90 d. and in equinoctiall decliners is alwayes equall to the angle, between the two meridians, is thus found.

As the whole sine,
Is to the sine of the latitude,
So is the tangent of the declination,
To the tangent of the angle between the two meridians.

In all the rest thus.

As the cotangent of the declination B N and B S in the South, or A S in the North,
Is to the tangent of the heigth of the stile R P in both,
So is the cosine of the arch of the meridian betwixt the zenith and the plane N O, or S O, and S a in both,
To the sine of the arch of the plane betwixt the meridian and substile R O and R a in both, by the thirteenth of the fourteenth of Finkius.

5 The angle betwixt the two meridians O P R in the foresaid schemes, is found by this one generall rule in all kindes.

As the sine of the arch of the meridian betwixt the pole and the plane P O and P a,
Is to the sine of 90 d. P R O, and P R a,
So is the sine of the arch of the plane betwixt the substile and meridian O R, and a R,
To the sine of the angle betwixt the two meridians O P R, by the first and second of the fifteenth case of R S. *Triangles.*

These

These things being found, the houre lines for all kinde o
planes are calculated by these two Canons:

The first for all paralell houre lines, is the second case of R
plane Triangles.

As the Radius,
Is to the length of the stile in any known parts,
So is the tangent of each houres equinoctiall distance from the sub stile,
To the same houres distance upon the equinoctiall in parts of th stile.

The second serves for all the rest, which is the first of th
fift case of *R.S.* Triangles.

As the whole sine,
Is to the sine of the heigth of the pole above the plane,
So is the tangent of each houres distance from the substile upon th equinoctiall,
To the tangent of the same houres distance from the substile upo the plane.

Thus have you for more readinesse sake the whole doctrin
of *Dialling* contracted into a sheet of paper.

I now come to the making of the particular Dials, in num
ber 25, as *Wittakindus* and others following him have recko
ned them, which *Clavius* in the second Chapter of his *Gnomo
nices* reduceth to 17, denominating the planes and Dials fro
nine great circles of the Sphere, to which they are parelell, an
allowing to every plane two faces, except the horizontall; bu
because the Diall of each face of every plane is one and the same
(by which reason there should bee but nine sorts of Dials) an
that the divers situation of the same kinde of planes enforcet
a differing projection of the houre lines, as they are right, ob
lique, or paralell to the axis of the world, I retaine the numbe
but take liberty to depart from the division. And further, I de
nominate each Diall and plane from the site of the axis, and re
spect of the poles thereof, it being most agreeable in all (but th
horizontall) to the vulgar names, by which they are best know
but chiefly because I finde that *Clavius* in the abovesaid Chap
ter is forced (for more plainesse sake) to do the same, who be
sides the paralellisme of each plane, describeth the erect plane

b

by the ſite of their poles, the inclining planes by their reclination, and the declining inclining by the ſite of the poles and reclination, ſo hee calleth that plane whoſe face reſpecteth the South, but deviateth from the prime verticall Northward, a South declining Eaſt, which is the true ſituation of the pole thereof, whereas it is manifeſt, that the plane it ſelfe declineth ſo much from the Eaſt Northerly, as the pole doth from the South Eaſterly, ſo he calleth inclining to the horizon, that which reſpecteth the zenith, and the South or North parts, whereas all inclinations looke down to the Nadir, and the reclining part of the plane up to the zenith, wherefore I call the horizontall, verticall, becauſe the pole thereof lieth in the vertex, or zenith of the place; the verticall I call South and North direct, becauſe the poles of the plane lie in the South and North part of the horizon; the meridian plane I call Eaſt and Weſt direct, becauſe the poles thereof lie in the Eaſt and Weſt part of the horizon; the equinoctiall I call polar, becauſe the poles of that plane lie in the poles of the world; and the polar I call equinoctiall, becauſe the poles thereof lie in the equinoctiall, and ſo of the reſt. Laſtly, I call all planes whoſe upper faces reſpect the zenith, recliners, and only their oppoſites incliners, whoſe nether faces look down to the Nadir.

The names and number of the Dials, are as followeth.

1 *Verticall, or Horizontall.*
2 *South and North direct.*
3 *Eaſt and Weſt direct.*
4 *South and North declining Eaſt or Weſt.*
5 *Eaſt and Weſt direct reclining or inclining.*
6 *Equinoctiall or South reclining, or inclining to the pole.*
7 *South direct reclining, or inclining leſſe* } *than the pole.*
8 *South direct reclining or inclining more* }
9 *Polar, or North reclining, or inclining to the equator.*
10 *North direct reclining, or inclining leſſe* } *than the*
11 *North direct reclining, or inclining more* } *equator.*
12 *Equinoctiall, or South declining Eaſt or Weſt, reclining or inclining to the pole.*

13 *South declining East or West, reclining or inclining ab*
the pole.

14 *South declining East or West, reclining or inclining un*
the pole.

15 *Polar, or North declining East or West, reclining or*
clining to the intersection of the meridian and equato

16 *North declining East or West, reclining or inclining ab*
the intersection of the meridian and equator.

17 *North declining East or West, reclining or inclining un*
the intersection of the meridian and equator.

Note that in the making the particular Dials, I do someti differ from these generall Canons, for varieties sake.

CHAP. VI.

To draw the houre lines upon the verticall, commonly called horizontall plane, the elevation of the pole being given.

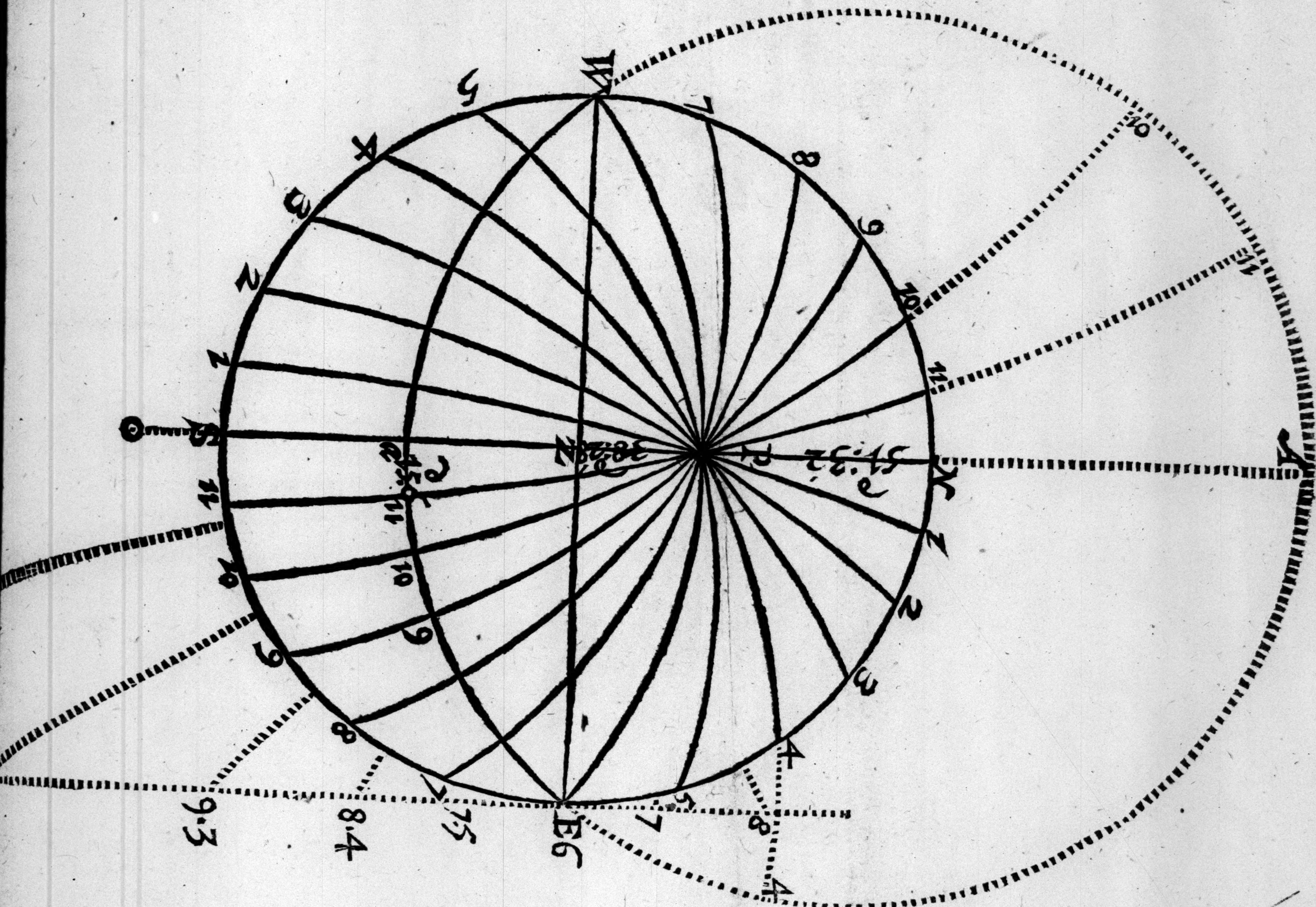
THis plane, in respect of the poles thereof, wh lie in the vertex and nadir of the place, may called verticall; in respect of the plane it se which is paralell to the horizon, horizonta Howsoever it be termed, the making of Diall is the same, in which first sort (as appe eth by the abstract) there is but only one arch of the merid betwixt the pole of the world and the plane required to the tificiall projecting the houre lines upon the same, which be the heigth of the pole above the horizon (equall to the heigth the stile above the plane) is alwayes given, by the help wher we may presently proceed to calculate the true houre distanc in manner following.

The Demonstration.

In this particular schem adjoyning, which is so much of t fundamentall schem as is pertinent to this purpose, let N E S be the horizon, N Z S the meridian, E Z W the prime vertic E æ W the equator, P the North pole, and Z the zenith,

hou

houre circles crossing at P, fall upon the horizon at the ointes fo



Place this folio 75.

dist

houre circles crossing at P, fall upon the horizon at the ointsp fo 11, 10, 9, 1; 2, 3, &c. limiting the distance of each houre line from the meridian upon the plane, according to the arches of y horizon N 11, N 10, N 9, &c. which by the severall triangles SP 11, SP 10, SP 9, or their verticals NP 11, NP 10, NP 9, may thus be found. Because every quarter of the horizontall is alike, you may begin with which you will, and resolve each houres distance either by the small triangle NP 11, or by the quadrantall AP 11, (supposing the equator and meridian to be continued, till they crosse each other at A, without the limb) or by the verticall triangles æ P 11, and NP 11, together as they lie in the schem, such is the variety of triangles. The arithmeticall calculation in the triangle P N 11. The side P N is given, the heigth of the pole above the horizon, 51 d. 32′, and the angle at P is given, one houres distance from the meridian, whose measure in the equinoctiall A 11, is 15 d. and the right angle at N or A is alwayes 90 d. wherefore by the first variety of the fift case of right angled S. triangles.

		Log.
As the sine of P N 11	90d. 0′	10000.00
Is to the tangent of the angle N P 11	15 0	9428.05
So is the sine of the side P N	51 32	9893.74
To the tangent of the side N 11	11 51	19321.79

Or againe, you may finde the same arch by help of both triangles together, NP 11, and æ P 11, because they be verticall, and their like sides proportionall.

		Log.
For as the sine of P æ	90d. 0′	10000.00
Is to the sine of P N	51 32	9893.74
So is the tangent of æ 11	15 0	9428.05
To the tangent of N 11	11 51	19321.79

Seeke in the Canon at the end of the booke for the tangent, 9321.79 Logar. and you shall finde the arch answerable thereto 11 d. 51′ for the first houres distance off 1, and 11, on each side of the meridian, and thus must you in all respects finde the

 distance

diſtance of 2 and 10 of clock, by reſolving the triangle N P 10, by the ſame caſe, and of 3 and 9 of clock, by reſolving the triangle N P 9, and ſo of the reſt, wherein as the angle at P, encreaſeth, which for two houres is 30 d, for 3 houres 45 d, for 4 houres 60 d, and for 5 houres 75 d, ſo will the arches of the horizon N 10, N 9, N 8, and N 7, proportionally vary, and give each houres true diſtance from the meridian, which is the thing deſired, and becauſe every 6 houres is 90 d. diſtance upon the equinoctiall each from other, you may at the ſame worke finde 11 and 5, 10 and 4, 9 and 3, 8 and 2, & 7 and 1 of clock, by one addition, and ſubtraction, or two additions at the moſt, which will ſomewhat alſo ſhorten the work, as in this example may appeare.

		Log.
P A is	$90^{d}.\ 0'$	10000.00
A 10 the tangent of	30 0	9761.44
P N the ſine of	51 · 32	9893.74
Which added to A 10		
Giveth the tangent of N 10	24 20	19655.18
But ſubtract A 10 out of the Radius and P N, there will come forth the tangent of N 4 at the ſame work	$53^{d}.36'$	10132.30

The reaſon whereof is manifeſt in the ſchem aforeſayd, wherein the equator being continued, to croſſe the meridian at A, and the houre line the equator at 10, the proportion ſtandeth thus:

As the greater ſine A P,
Is to the leſſer ſine N P,
So is the greater tangent A 10,
To the leſſer tangent N 10,

which produceth 24 d. 20′ for 10 of clock, by addition, but if you put the radius in the ſecond place, which you may change at pleaſure, becauſe it is meane proportionall between the tangent of the arch, and complement, by the 25 of the 5 of *Finkius*, then will the proportion be,

As

As the leſſer tangent A 10,
Is to the greater ſine A P,
So is the leſſer ſine P N,
To the geater tangent N 4,
which giveth 53 d. 36′, found by ſubtraction, for 4 of clock, being 6 houres diſtance from 10.

To perform this by addition only, the proportions bee the ſame for both houres.

			Logar.
For as the whole ſine A P	90 d.	0	10000.00
Is to the tangent of *A* 10	30	0	9761.44
or			
A 4	60	0	10238.56
So is the ſine of P N	51	32	9893.74
To the tangent of *N* 10	24	20	9655.18
or			
N 4	53	36	10132.30

And thus having ſhewed divers wayes to calculate ſome of the houre diſtances, (which vary nothing at all from the reſt) and alſo how the proportions are naturally deduced out of the ſchem, I will now ſhew a briefe way to obtaine your deſire, which would have been both obſcure and prepoſterous, without underſtanding the reaſon of the work, by the former directions.

Firſt therefore prepare a table, according to the example adjoyning, wherein ſet down all the houres in order from 12, as they are equidiſtant from the meridian, *vizt.* 11 and 1, 10 & 2, 9 and 3, &c. unto them adjoyne the equinoctiall diſtances, that is, for the firſt houre 15 d, for the ſecond houre 30 d, for the third, 45 d, and ſo of the reſt, by continuall addition of 15 d. then take out of the Canon upon a looſe paper, the Logarithme or artificiall ſine of the elevation of the pole above this plane, which for 51 d. 32′, the heigth of the pole here at *London*, is 9893.7452, and is alwayes one of the middle proportionals; in finding out every houres diſtance, apply it to 9428.0524 the Logar. tangent of 15 d, in the booke, (which is the firſt houres equinoctiall diſtance) and adde them both together, there ſhall come forth a new Logar. tangent of 9321.7976 for that houres

 diſtance,

Houres.		Equinoct. distances.		The Logarith. of the tangents.	The true houre distances upon the plane.	Differ.
12	0	0d.	0'	0	0d. 0' 0''	
11	1	15	0	9321.7976	11.50.55	
10	2	30	0	9655.1845	24.19.29	12d.28' 34''
9	3	45	0	9893.7452	38. 3.35	13 44 6
8	4	60	0	10132.3058	53.35.43	15 32 8
7	5	75	0	10465.6927	71. 6.29	17 30 46
6	6	90	0	10000.0000	90. 0. 0	18 53 31
ante merid	post merid					

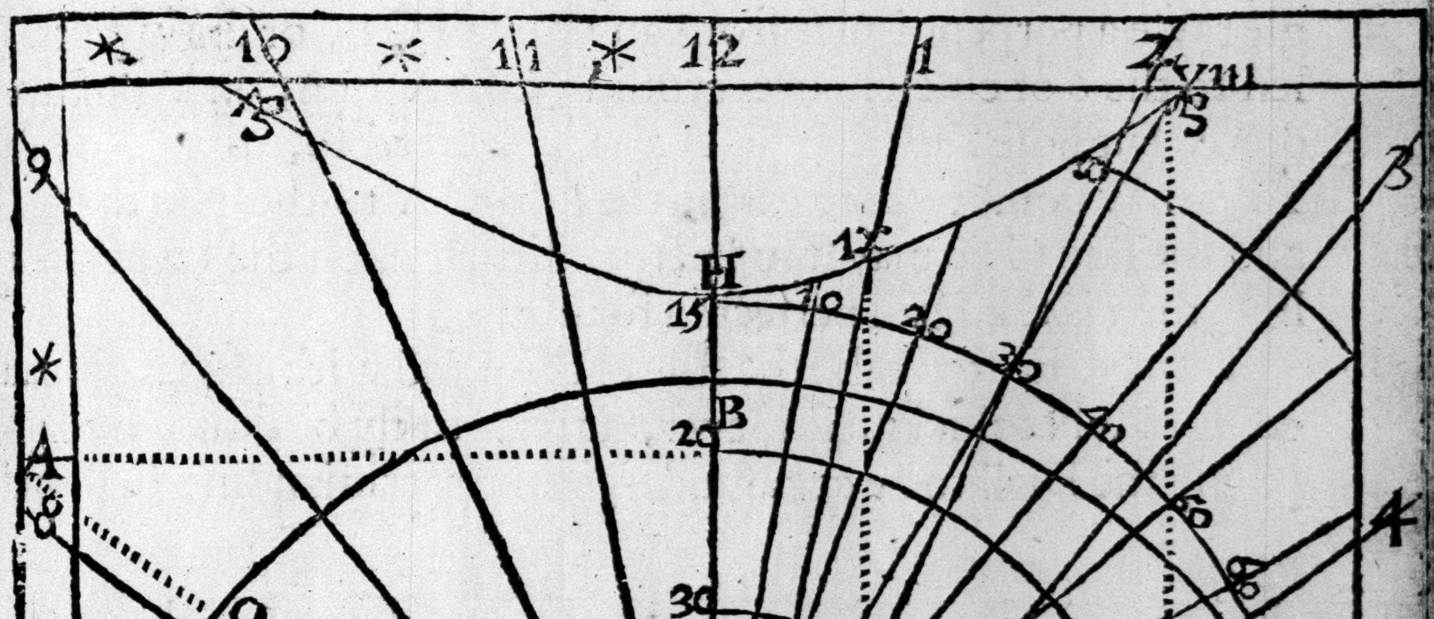
distance, which set down in the table by 15 d, in the same place, remove your paper, to the Logar. tangent of 75 d. the complement of 15 d. 10571.9475, and adde them both together, you shall produce a new Logar. tangent of 10465.6927 for the houres of 7 or 5, 90 d. distant from 11 and 1, which set down in the table also by 75 d, do the like with the tangents of 30 d, and 60 d, for the houres of 10 and 2, and 8 and 4, for the tangents of 9 and 3 of clock you must set down in the table, the artif. sine it selfe of 51 d. 32', *viz.* 9893.7452, because the tangent of 45 d. that houres distance from 12, (being equall to the Radius) altereth not the sine at all; now seeke these severall Logar. tangents in the Canon, and you shall finde the horizontall arches of each houres distance to be for N 11, and N 1, 11 d. 51'; for N 10, and N 2, 24 d. 20'; for N 9, and N 3, 38 d. 4'; for N 8, and N 4, 53 d. 36'; for N 7, and N 5, 71 d. 6'; the houres 12 and 6 of clock, are two streight lines 90 d. distant, ~~and the face~~ crossing each other at right angles, as N Z S representing the meridian, and E Z W representing the prime verticall, do in the schem.

The table being thus prepared, you may examine the truth of the work by the differences of the arches, for though they do not equally vary, yet is there such a circular proportion observed, that they neither alter suddenly, nor contrary one to another.

The

The Geometricall projection.

Now make the Diall, and firſt draw two ſtreight lines CB 12, and 6 C 6, croſſing at right angles in C, upon the center C, at the diſtance of Z S of the ſchem, equall to A B 60 d. of the leſſer chord, make the circle E B O S repreſenting the plane; ſet off from B upon that circle both wayes (by help of the former chord) the houre diſtances, as they lie in order in the table, *vizt*. 11 d. 51′ for 11 and 1 of clock, 24 d. 20′ for 10 and 2 of clock, 38 d. 4′ for 9 and 3 of clock, and ſo of the reſt. Thorow theſe pricks draw ſtreight lines from the center C, ſo have you



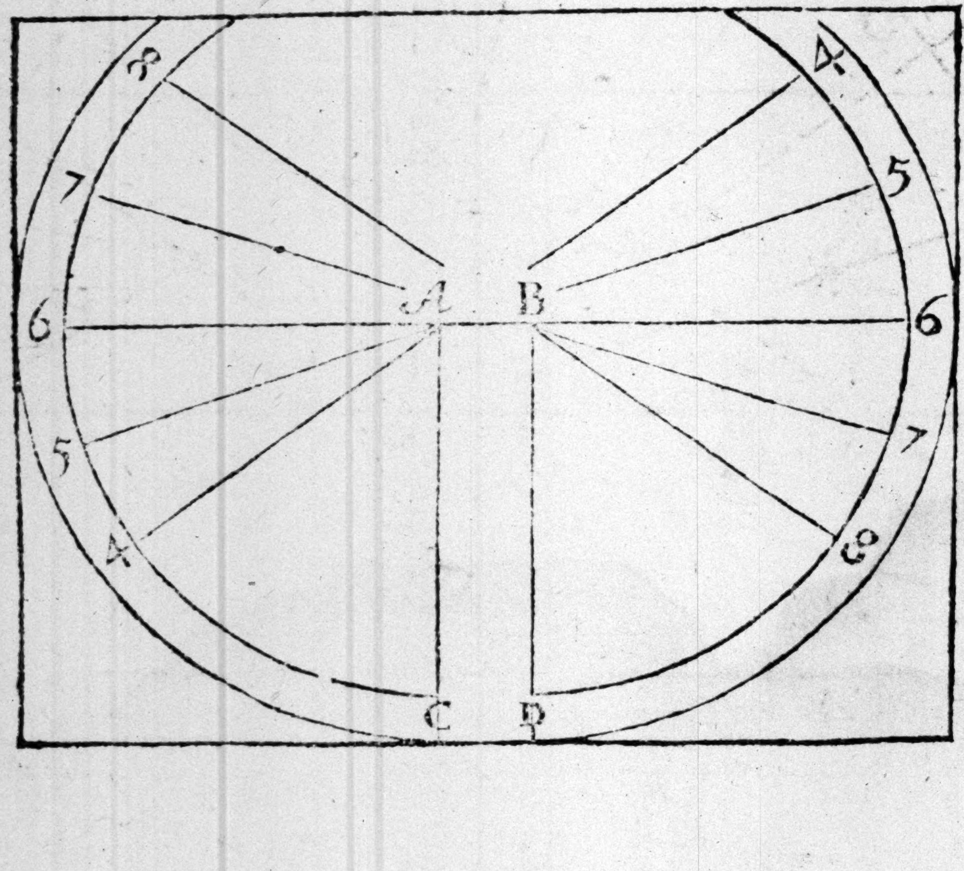
 all

all the houres for this plane, except those which fall above t
6 of clock houre, which are no other but the fourth and fift, t
seventh and eighth, houre lines continued beyond the center.

The heighth of the stile 51 d. 32′.

For the heighth of the stile you need no calculation in t
kinde of Diall, the heighth of the pole above the horizon be
given, is the heighth therof, take therefore of the same chord t
arch 51 d. 32′, and set it from B to O, either way ; from t
center thorow that point draw the prickt line C O A, wh
representeth the axis, or stile desired, if you like to make it a t
angular stile, which forme is fittest to support it, at the true
gle rayse a perpendicular from any part of C B, or draw a pa
lell to the 6 of clock houre, crossing C O A in A, and you ha
done. Suppose the triangle A 20 C, erected so, that the s
20 A may point to the zenith, the side C A to the North po
and the side C 20 may stand perpendicular upon the 12 of clo
line, then is the Diall perfected for use.

If any desire to make the stile of this Diall with a square bro
edge, of what thicknesse soever, it may easily be done, by su
posing the Diall to be cut asunder, in the meridian line C B, a



t

the Eaſt ſide ſeparated from the Weſt, the thickneſſe of the ſtile, A B D C, of this later ſchem, then ſhall all the houre lines under ſix remaine the ſame, only the houre lines of 5 and 4 in the morning, and 7 and 8 in the evening, which before were drawn thorow the center C of the firſt ſchem, at equall diſtances, above and under the *6* of clock houre, muſt now be drawn thorow the ſeverall centers A and B of the ſecond ſchem, and ſo will become unequall, ſave with reference to their proper centers ; notwithſtanding, becauſe the Eaſt edge of the ſtile ſheweth the houres before *6*, and the Weſt edge thereof after *6*, the ſhadow ſhall give the true houre, as when both ſides were drawn thorow one and the ſame center : the azimuthes, almicanters, paralels, &c. remaine the ſame without alteration, only the *nodus* or notch in the ſtile, which traces out theſe lines, muſt bee made at the like diſtance on each ſide of the ſtile ; the like may bee done in all other kindes of Dials, ſuppoſing the ſubſtile to be devided, as here the meridian is.

Now if you deſire to put into this Diall, or any of the reſt that follow, the halfe houres and quarters, their diſtances upon the plane are as eaſily found by the ſame rules, as the houres were, for by adding the Log. ſine of the heighth of the pole unto the Log. tangents of 3 d. 45′, 7 d. 30′, and 11 d. 15′, which are the equinoctiall arches of halfe houres and quarters, there will come forth the Log. tangents of new arches, proper to the halfes and quarters, as in the example appeareth, which being found in the canon, and put into the Dyall by help of the chord, as the houres were, you have done what was deſired.

Hour	Quart.	Equino. diſtance.	Logarith. tangents.	True ho. diſtance.	Differ.
12	0	0^{d}. 0′	0000.00	d ′	d ′
	1/4	3. 45	8710.27	2.56	2.57
	1/2	7. 30	9013.17	5.53	2.58
	3/4	11.15	9192.40	8.51	3. 0
11	0	15. 0	0000.00	0. 0	3. 2
	1/4	18.45	9424.52	14.53	3. 5
	1/2	22.30	9510.96	17.58	3. 9
	3/4	26.15	9586.71	21. 7	3.13

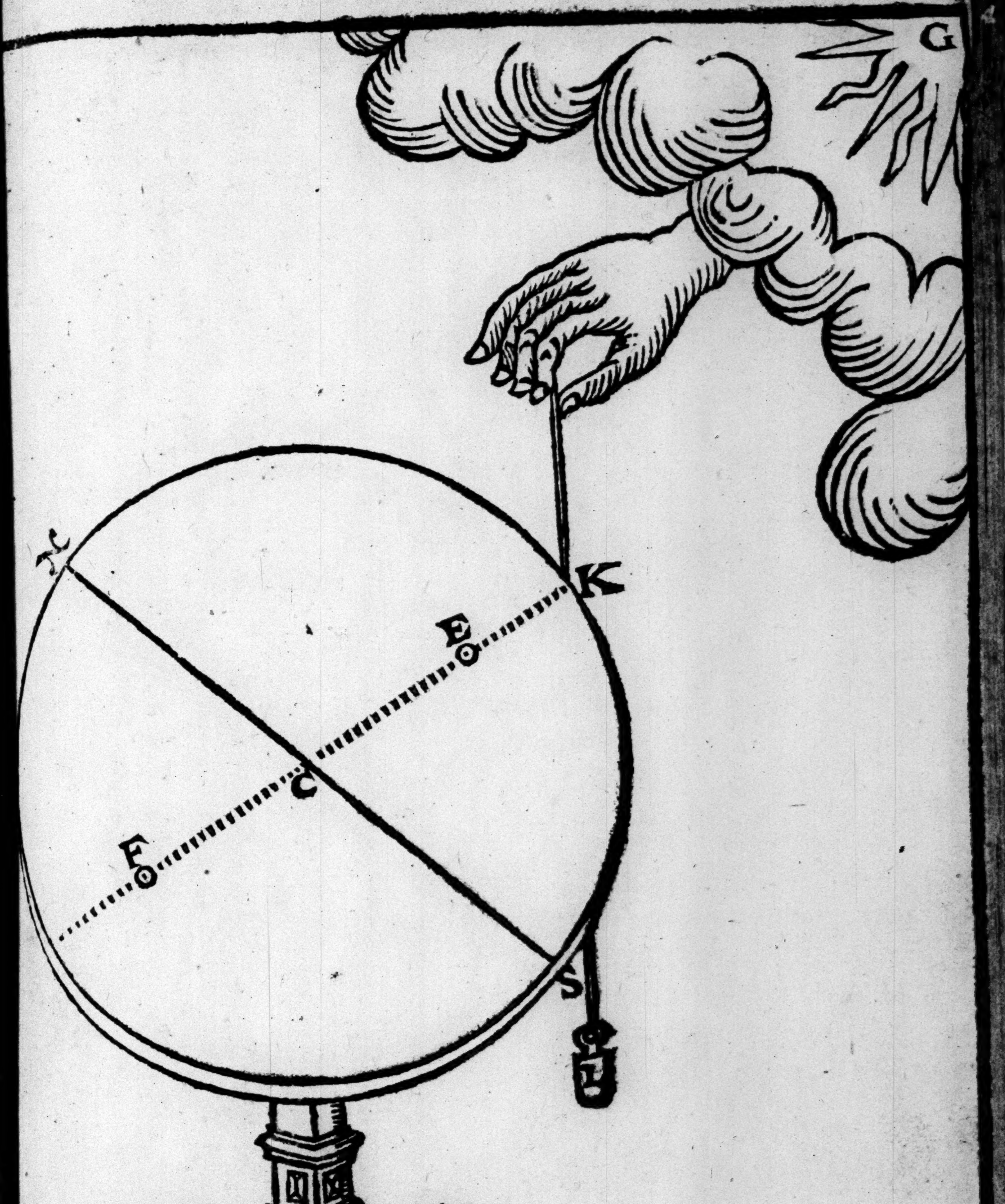
Hour.	Quart.	Equino. distance.	Logarith. tangents.	True ho. distance.	Differ.
10	0	30d.0′	0000.00	0d. 0′	3.17
.	1/4	33.45	9718.63	27.37	3.23
.	1/2	37.30	9778.72	31. 0	3.29
.	3/4	41.15	9836.73	24.29	3.35
9	0	45. 0	0000.00	0 0	3.42
.	1/4	48.45	9950.75	41.46	3.49
.	1/2	52.30	10008.76	45.35	3.56
.	3/4	56.15	10068.85	49.32	4. 4
8	0	60. 0	0000.00	0 0	4.12
.	1/4	63.45	10200.76	57.48	4.19
.	1/2	67.30	10276.51	62. 7	4.27
.	3/4	71.15	10362.96	66.34	4.32
7	0	75. 0	0000.00	0 0	4.39
.	1/4	78.45	10595.08	75.45	4.42
.	1/2	82.30	10774.31	80.27	4.46
.	3/4	86.15	11077.21	85.13	4.47

Now because it is to little purpose to make the Dyall true,unlesse you also place it true in the meridian, I think it fit in this placeto shew the manner of finding a meridian line,at any time of the day, the Sunne shining.

Hold a thred with a weight at the end thereof, close to the plane, on which you purpose to set the Diall, represented by the round table N K S ; make two pricks in the shadow of the thred upon the plane, by which draw a streight line, at the same instant take the heighth of the Sunne,and by help thereof finde the azimuth of the Sunne, which (with the complement thereof to 180 d.) being set Northwards, and Southwards, from the line of shadow (in the circle S K N first drawn by a chord) according to the time of observation shall give two points, by which a streight line drawn thorow the center C, representing the zenith, shall be the true meridian line desired.

Example, let the plane be N K S, the thred and weight K L, the shadowed line E C F, two pricks therein at E and F, the

heighth



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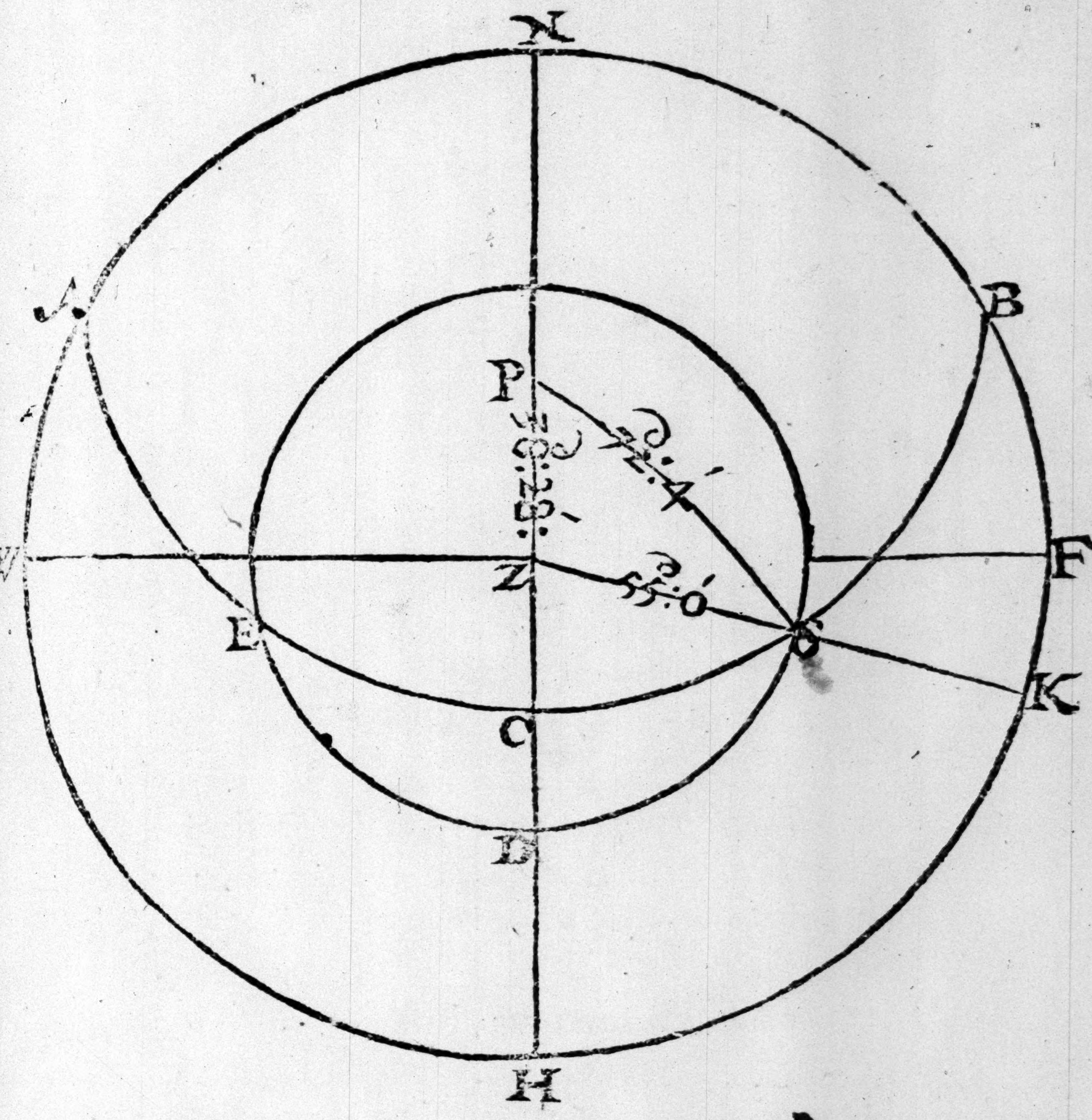


heigth of the Sunne in the morning on the East side of the meridian 35 d. you must therefore resolve the oblique triangle PZS in the schem adjoyning, consisting of these three great circles of the sphere, *vizt.* ZP part of the meridian of the place, PS part of a great circle limiting the declination of the Sunne in the paralell of ACB, and ZS part of the azimuth giving the heighth of the Sunne in the almicanter EDS, wherein ZP the complement of the elevation is given 38 d. 28′, and ZS the complement of the Suns heighth is found by instrument 55 d. and PS the complement of the declination may bee had out of Mr. *Wrights* booke of Navigation, or the like, or may bee calculated having the place of the Sunne by the first of the first case of *R. S.* triangles, and is in this instance supposed to be on the

the 1 of May 1622, about 8 of clock in the morning 72 d. 4′, by these three sides given, we seek the angle at Z, which gives the distance of the Sunne in the horizon N W H F, either from the North or South part of the meridian N Z H, by the first case of oblique sphericall triangles.

The first way by tangents.

The base P S	72^d. 4′			
The sides *Z S*	55 0			
The sides *Z P*	38 28			
The summe	165 32	Logar.		
The halfe	82 46	0003.4701	*Arith. compl.*	
The difference	10 42	0731.2662	*Arith. compl.*	
The difference	27 46	9668.2665		
The difference	44 18	9844 1137		
Totall		20247.1165		
The halfe		10123.5582	*Is the Logarith.*	
tangent of halfe the angle				53 d. 2′ 30″
Therefore the whole angle K Z N				106 5 0

The second way by sines.

The base P S	72^d. 4′	Logar.		
The sides *Z S*	55 0	0086.6355	*Arith. compl.*	
The sides *Z P*	38 28	0206.1683	*Arith. compl.*	
The summe	165 32			
The halfe	82 46	9996.5298		
The base subduct	10 42	9268.7338		
Radius & seventh propor.		19558.0674		
The halfe thereof		9779.0337	*Is the Log.*	
sine of halfe the angle				36^d.57′ 30″
Therefore the whole angle KZH				73 55 0

But you must remember that the first operation giveth the angle Z, reckoned from the North, as it naturally lieth in the Sphere, the second giveth the angle reckoned from the South,

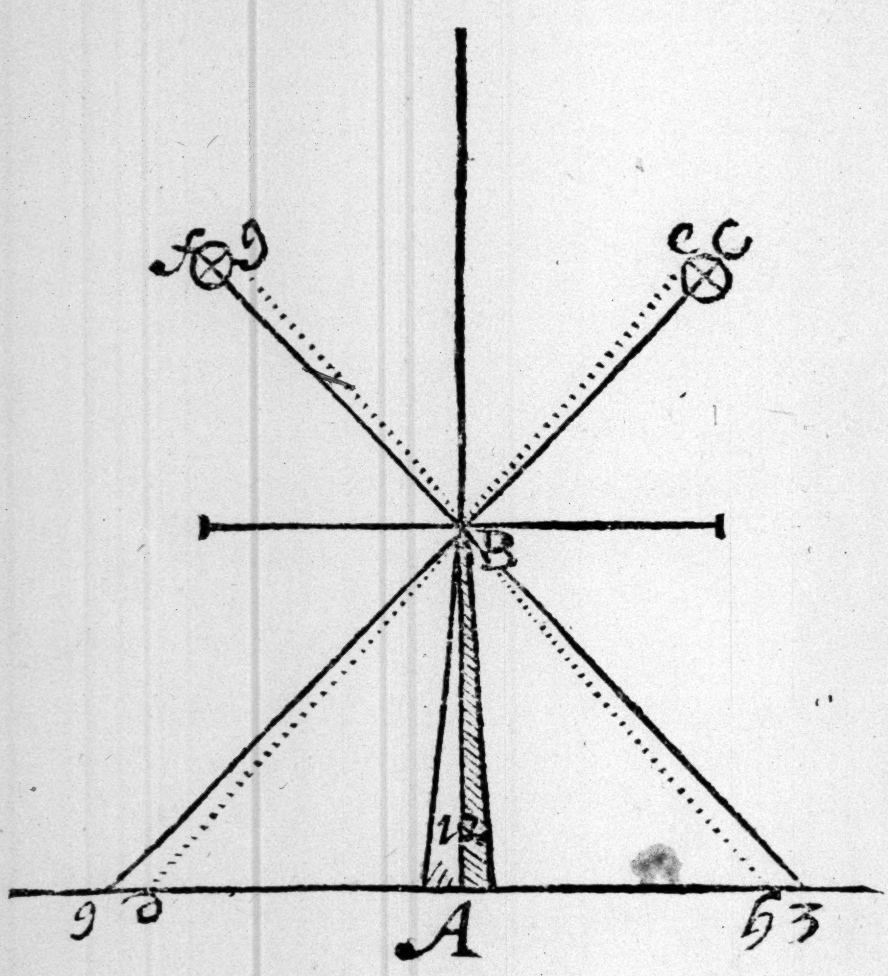
which

which is the complement of the former, and in this case is more apt for our purpose. Take therefore off a chord fitted to the Radius C N 73 d. 56′, and set it from the line of shadow Southwards to S, or 106 d. 4′, and set it from the line of shadow Northward to N, and by these two points draw a line thorow the center C, and N C S shall be a true meridian line, whereupon you must place the 12 of clock houre line of your Dyall.

But it may be objected, that notwithstanding all this paines, neither this, nor any other Diall, shewes the time exactly true, without correction, and allowance for the semidiameter of the Sunne, which is generally omitted by all Authours. I grant, that in a strict acception this is true, but seeing that sense must be our judge, and Scale and Compasse our instruments, such curiosity might be safely neglected, yet the rules of Art remaine unblamable.

To answer this objection, it cannot be denied, that the true houre line of every Diall is the shadow of the axis, cast by the center of the Sunne upon the opposite part of the meridian, intercepted by the plane, but because the shadow of the center is hindred by the stile, the shadow of our houre lines proceedeth from the limb, which alwayes precedeth the center one minute of time, answerable to 15′ the semidiameter of the Sunne. To allow this in the heighth of the stile, is erroneous, because every stile representing the axis, ought to be paralell thereto; but if wee abate for the horizontall at *London* 15′, the semidiameter of the Sunne, out of 51 d. 32′, the heighth of the stile, and make the stile to 51 d. 17′, or for a South Diall, to 38 d 13′, wee shall cause the stile to point so many minutes under each pole, which put it out of paralellisme with the axis, and consequently makes it give a false shadow upon the plane. Let the stile therefore bee kept to the true elevation, and let the allowance bee made in the equinoctiall distances of the houre lines, contracting them one minute of time, on each side the meridian, or substile respectively: in regard that the shadow of the verge doth always precede the shadow of the center so much. So shall it come to passe, that when the limb of the Sunne doth give shadow to the houre line upon the plane, one minute sooner or later then it should do, the center of the Sun shall at the same time be just upon

on the meridian, represented by the same as in this diagramme doth appeare. Wherein suppose A B to bee the length of the perpendicular stile, in the forenoone the true houre line drawn from the center of the Sunne is C 9, which the verge of the Sun sheweth at e d, one minute of time sooner than it should; contract the houre line C 9 one minute, it will fall upon the prickt line e d; againe in the afternoone, the true houre line drawn from the center of the Sunne is f 3, which the verge of the Sun sheweth at g h, one minute of time later than it should;



contract the houre line f 3 one minute, it will fall upon the line g h; wherefore it followeth, when the verge of the Sunne e or g giveth shadow upon the houre lines contracted e d & g h, the center of the Sunne would at the same time shine upon the true houre lines C 9, and f 3, if the Apex of the stile at B did not hinder the same. In imitation of this example for the horizontall, the true houre lines (according to this strict acception by abating fifteen minutes in each houres equinoctiall distance, answering to one minute of time) may bee cast up for all other kinde of Dials whatsoever,

Houres

Houres		Equi.dist.		Log.tangents	True ho. dist.		
		d	'		d	'	"
12	0						
11	1	14	45	9314.1598	11	38	51
10	2	29	45	9650.7972	24	6	31
9	3	44	45	9889.9552	37	49	2
8	4	59	45	10127.9405	53	19	12
7	5	74	45	10458.1594	70	48	6
6	6	89	45	12253.9250	89	40	51

CHAP. VII.

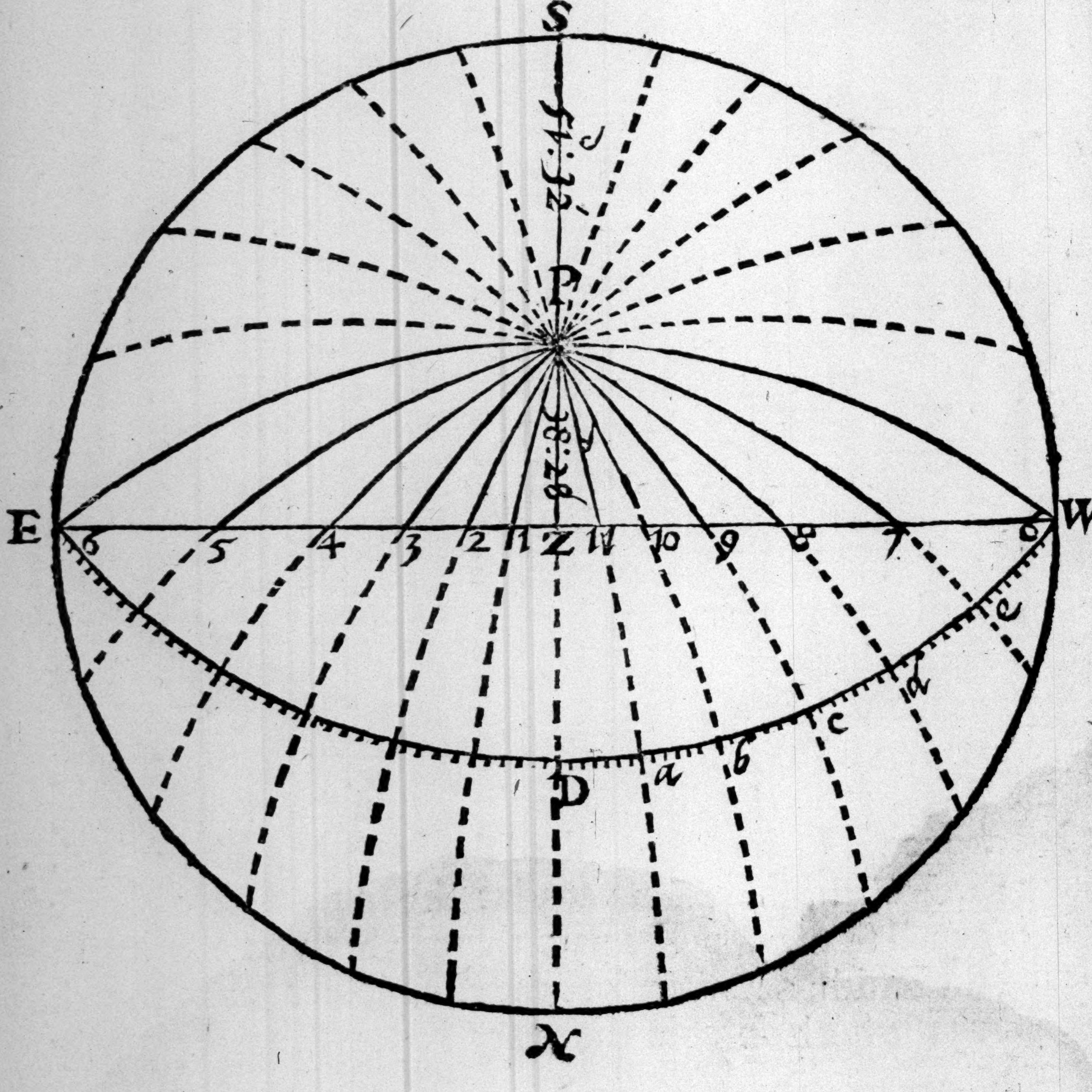
To draw the houre lines upon a direct South plane, the heighth of the pole being given.

EVery perpendicular plane, whether direct or declining, lieth in ſome azimuth or other, as here the South wall or plane doth in the prime verticall, or azimuth of East and West, repreſented in this ſchem, by the line E Z W, and therefore it cutteth the meridian of the place at right angles in the zenith, and hath the two poles of the plane ſeated in the North and South interſection of the meridian and horizon, and becauſe the plane hideth the North pole from our ſight, we may therefore conclude (it being a generall rule, that every plane hath that pole depreſſed, or rayſed above it, which lyeth open unto it) that the ſouth pole is elevated thereupon, and the ſtile of this Diall muſt looke downwards thereunto, erected above the plane the heigth of the antartick pole, which being an arch of the meridian betwixt the ſouth pole and the nadir, is equall to the oppoſite part thereof betwixt the north pole and the zenith, and therefore the complement of the north pole above the horizon, as in the next Chap. will more plainely appeare.

The

The Demonstration.

Suppose then that P in the schem, drawn by the rules of the fourth Chapter, be now the south Pole, and S the south part of the meridian, N the north part &c. then do all the houre circles from the pole cut the line E Z W, representing the plane unequally, as the houre lines will do upon the plane it selfe, and as by the figures in the schem set unto every houre line thereof doth appeare. Now having already the elevation of the pole given, as was in the horizontall, there is nothing else to bee done, but to calculate the true houre distances upon the line E Z W, from the meridian S Z N, and then to proceed as for-



merly

merly, and note, because the houres equidistant on both sides the meridian, are equall upon the plane, the one halfe being found, the other is also had, therefore you may begin with which side you will.

In the triangle Z P 11, right angled at Z, I have Z P given 38 d. 28′, the complement of the heighth of the pole, which is the heighth of the stile to this Diall, and the angle at P 15 d. one houres distance from the meridian upon the equator, to finde the side Z 11; or if you will draw the equinoctiall circle E D W, it will bee more proper in the quadrantall triangle P D *a*, wherein the quadrant P D is given 90 d, the side D *a* is given 15 d. of the equinoctiall, the measure of the angle P, and the side P Z is given, 38 d. 28′, to finde the side Z 11, as before by the variety of the fift case of R. S. triangles. For,

The Arithmeticall calculation.

As the sine of P D	90^{d}.	0′	10000.00
Is to the tangent of D A	15	0	9428.05
So is the sine of P Z	38	28	9793.83
To the tangent of Z 11	9	28	~~1~~9221.88

which 9 d. 28′ is the true distance of the houres of 1 and 11 from the meridian upon the plane.

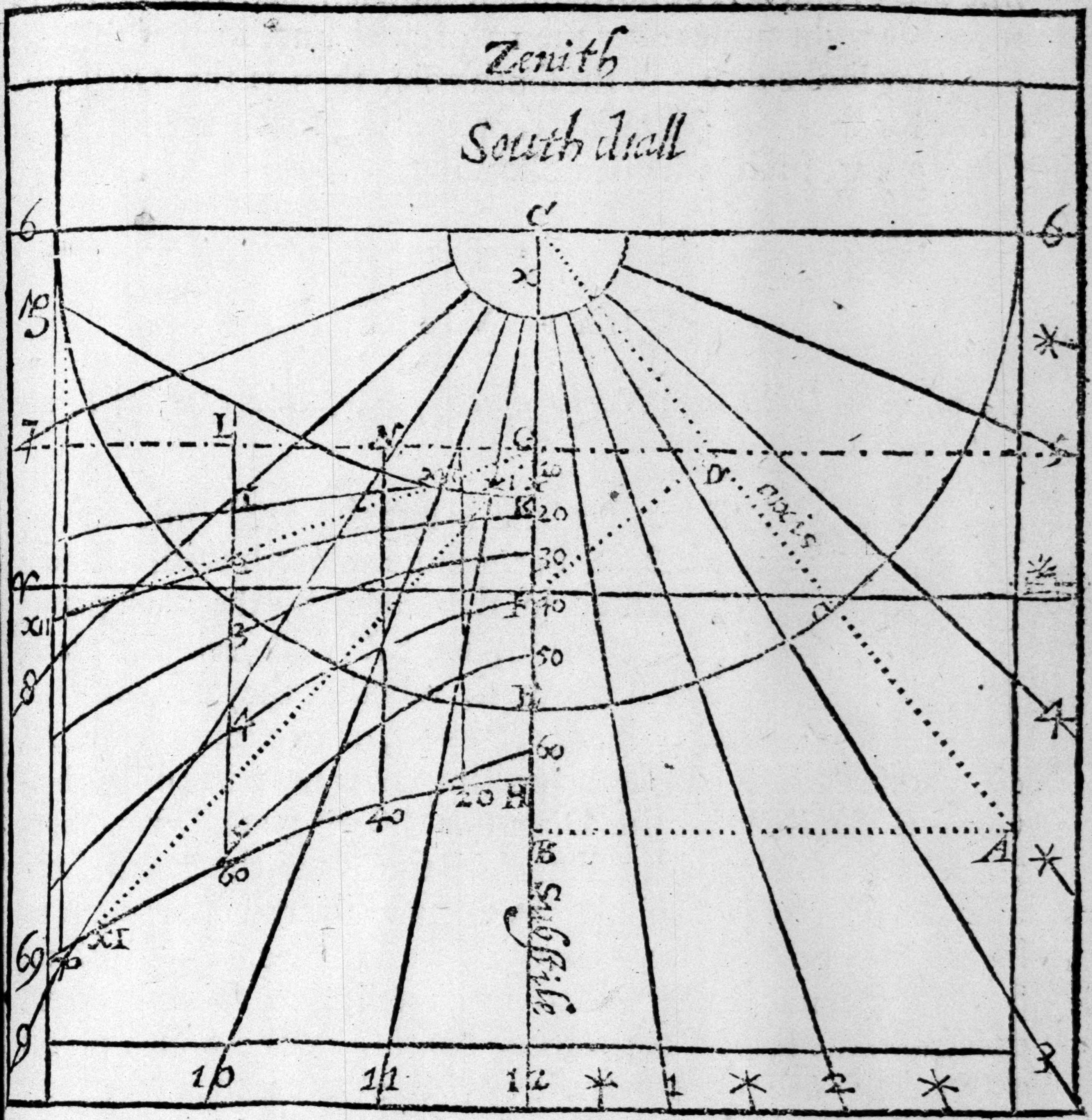
And because there is no other variety in calculating the rest of the houres, but only changing the angles at P, which encrease 15 d. for every houres distance from the meridian, therefore as you did in the horizontall, first make a table like the example adjoyning, wherein set down all the houres and halfe houres from the meridian, with the equinoctiall distances by them, of 7 d. 30′ for halfe houre after 12, 15 d. for 1 and 11, 22 d. 30′ for halfe houre after 1, &c. then transcribe the Logarithmicall sine of 38 d. 28′. 9793.83. (which in this Diall is the heighth of the stile above the plane) into a peece of paper, and adde it unto the severall Logar. tangents of the equinoctiall distances of the houres and halfe houres, so shall you produce other Log. tangents, which set down in the table, and sought in the Canon, will give you the true houre arches to bee set off from the point E of the meridian line in the Diall, each way upon the circle E o 6, representing the plane, as in the table annexed appeareth.

Houres & Halves.		Equioct. distance.	Logarith. of tangents.	True houre distance upon the plane.	
		d '		d '	Differ.
12	0				
.	½	7.30	8913.26	4.41	4.47
11	1	15. 0	9221.88	9.28	4.59
.	½	22.30	9411.05	14.27	5.18
10	2	30. 0	9555.26	19.45	5.46
.	½	37.30	9678.81	25.31	6.22
9	3	45. 0	9793.83	31.53	7. 9
.	½	52.30	9908.84	39. 2	8. 6
8	4	60. 0	10032.39	47. 8	9.12
.	½	67.30	10176.60	56.20	10.22
7	5	75. 0	10365.77	66.42	11.21
.	½	82.30	10674.40	78. 3	11.57
6	0	90. 0	10000. 00	90. 0	
The heigth of the stile 38 d. 28'.					

Where the Log. tangent of 1 & 11 produced by adding the Logar. sine of 38 d. 28' unto the Logarith. tangent of 15 d. is 9221.88 (the Radius being cut off, as in the cautions aforesayd) the arch whereof is 9 d. 28'. So is the Log. tangent of 5 & 7 produced by the like addition of the Log. sine of 38 d. 28' unto the Logar. tangent of 75 d. 10365.77 the arch whereof is 66 d. 42', the like may bee sayd of the rest of the houres 2 and 10, 3 and 9, &c. but because I have so particularly delivered all the operations in the horizontall, I may here forbeare to do the like, and referre you to the table.

The Geometricall projection.

In the making of the Diall, first draw the perpendicular line C E B, which is the 12 of clock houre, crosse it at right angles with 6 C 6, which is the 6 of clock houre, then take 60 d. of the chord, equall to Z S the Radius of the schem, and making C the center, draw the circle 6 E 6, representing the azimuth, in which the plane lieth, which done, take off the chord all the houre



houre distances, *vizt.* 9 d. 28′ for 1 and 11, 19 d. 45′ for 2 and 10, 31 d. 53′ for 3 and 9, and so of the rest, and set them from E (the intersection of the meridian and plane) both wayes upon the circle 6 E 6; streight lines drawn from the center C to those pricks in the circle, are the true houre lines desired.

Having drawn all the houre lines, take 38 d. 28′ (the elevation of the pole or stile above this plane) off the same chord, and set it from E to o, draw the prickt line C o A, representing the axis, or heighth of the stile, from any part of the meridian, draw a paralell line to 6 C 6, as is B A, and it shall make a triangle the fittest forme to support the stile at the true heighth; let the

line 6 C 6, and B A be horizontall, the triangular ſtile C B A erected at right angles over the 12 of clock line, ſo that the axis C A may looke down to the ſouth pole, then is the Diall perfected for the plane, directly repreſenting ſouth or north, as ſhall appeare in the Chapter following.

CHAP. VIII.

To make a Diall to a North direct plane, the oppoſite to the former.

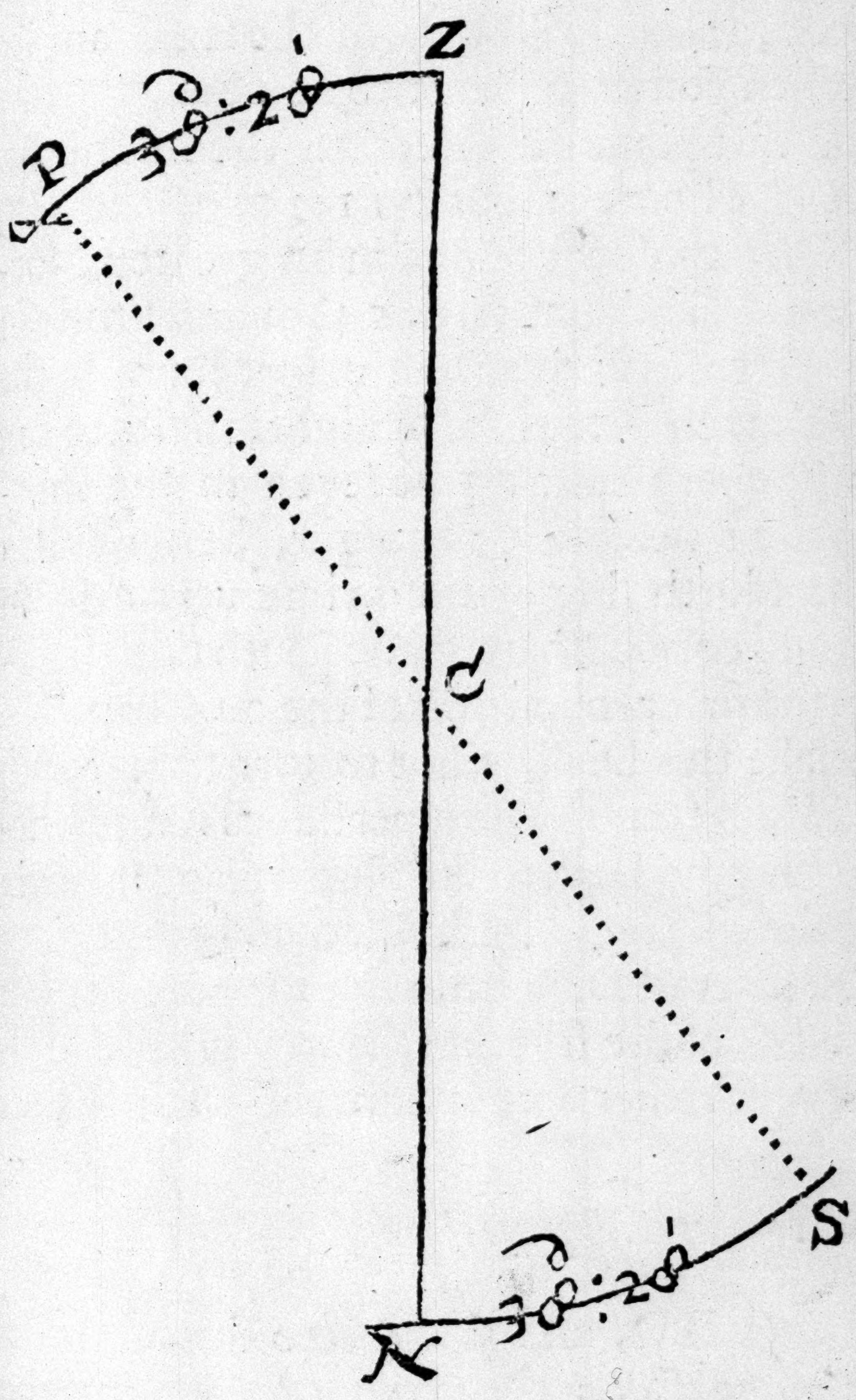
THE north plane is but the back ſide of the ſouth, lying in the ſame azimuth with it, and is repreſented in the ſchem by the back part of the ſame ſtreight line EZW, & as in this plane, ſo is it in all others, whether they bee direct, or declining, or reclining, or declining reclining, every one hath two faces, reſpecting contrary parts of the heavens, the making of the Dials not differing at all, the South plane hath the North, the Eaſt plane the Weſt, the South declining Eaſt a North declining Weſt, and the reclining plane an inclining oppoſite to it, whatſoever therefore is ſayd of the South plane, may be applied to the North, and ſo of the reſt, excepting the reſpect of the ſtile, becauſe as the South pole is above the South plane an angle of 38 d. 28′, ſo is the North pole under the North plane the like, and equall angle, and each ſtile muſt reſpect his owne pole.

The Demonſtration.

To make this plane, conſider the diagram adjoyning, wherein Z C N repreſenteth a South and North wall erect direct, Z the zenith, N the nadir, and C the center of the world, P C S the axis, Z P and N S two arches of the meridian, therein P the North pole, diſtant from Z the zenith, and depreſſed under the North ſide of this plane the angle of P C Z, 38 d. 28′, and ſo much is the South pole S diſtant from the nadir N, and elevated

above

above the South side of this plane, the angle of N C S 38 d. 28', equall to the former, as may be easily proved, because the angles at Z and N are right angles, and P and S subtented by like sides are equall by the work, and the angles at C are verticall, N C S is therefore the heighth of the stile for the South wall, which must looke downwards to the South Pole S, & Z C P is the heighth of the stile for the North wal, which must look upwards to the north pole P. And because there may bee hereafter no doubt, how to place the stile, which giveth the shadow to the houres in every Diall, observe this generall Rule. The side of the stile representing the axis must alwayes respect one of the poles, *videlicet*, in all erect planes, whether direct, or declining upon the North side, the North pole; upon the South side, the South pole, as in P Z N, the pole P, but in S N Z, the pole S; in all East and West reclining, the North pole, in inclining East and West, the South pole; in all North reclining planes, whether direct or declining, the North pole; and in the inclining planes, opposite to them, the South pole; lastly, in all South reclining planes, whether direct or declining, if the plane passe between the zenith and the pole, the



axis

axis of the ſtile muſt reſpect the South pole, and on the inclining ſide, the North pole; but if the plane paſſe between the horizon and the pole, the contrary.

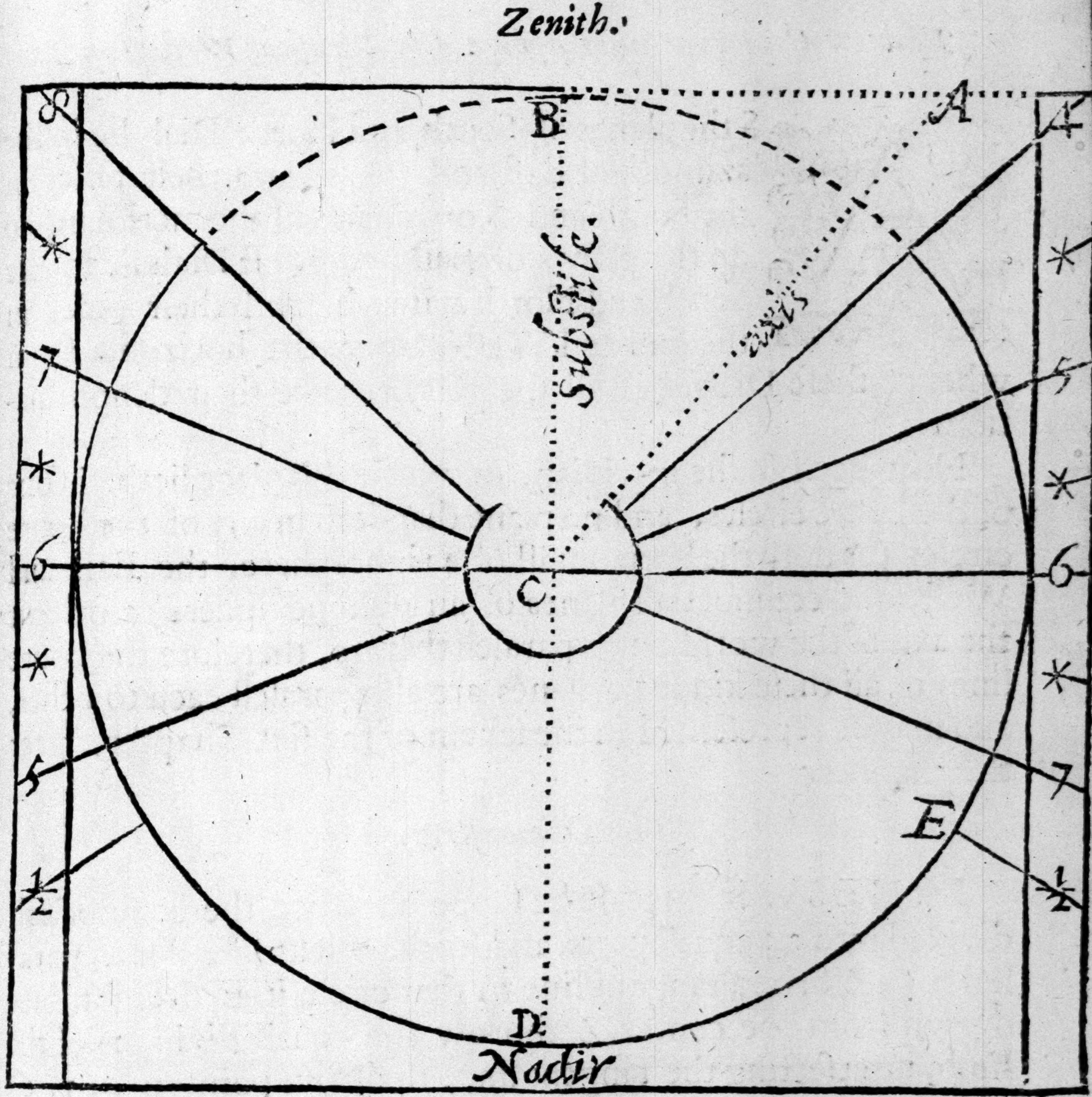
Suppoſe therefore againe in the firſt ſchem of the former Chapter, P to bee the North pole, and the ſide E Z W objected to it, to be the North wall or plane, then do all the houre circles drawn from the pole cut the line E Z W with the ſame angles that they did before, when you ſuppoſed it to be a South plane, only the meridian upon this plane repreſenteth the midnight, and not the noone, and the houres about it 11, 10, 9, and 1, 2, 3, are altogether uſeleſſe, becauſe the Sunne in his greateſt Northern declination ~~23 d. 54~~′, hath but 39 d. 54′ of amplitude in this our latitude, and therefore riſeth but 13′ before foure in the morning, and ſetteth ſo much after eight at night, neither can it ſhine upon this plane longer than 21′ paſt ſeven in the morning, and returning to it 21′ before five at night, becauſe then the Sunne paſſeth off the North ſide of the prime verticall, in which this plane lieth, and commeth upon the South ſide thereof, as doth appeare by the firſt propoſition of the 34 Chap.

Now therefore to make this Diall, is but to turne the South Diall upſide down, and leave out all the ſuperfluous houres between 5 and 7, 4 and 8, and the Diall to the North plane is made to your hand. Theſe things conſidered, I ſee no reaſon why this ſhould be reputed a ſeverall Diall from the former, which agreeth both in the heighth of the ſtile and houres with the other, notwithſtanding for further ſatisfaction the Diall is thus eaſily made.

The Geometricall projection.

Draw two ſtreight lines B D, and 6 C 6, croſſing at right angles in C, open your compaſſes to the extent of 60 d. of the chord, and upon the center C make the circle E B D, repreſenting the azimuth wherein the plane lieth: out of the former table calculated for the South Diall, take the houre diſtances of 4 and 8, which is 47 d. 8′, and of 5 and 7, which is 66 d. 42′, and ſet them from the point B of the meridian line B C, upon the circle E B D, both wayes, ſo ſhall you have pricks, unto which from C draw ſtreight lines for the houres deſired, continue the houre

Heighth of the ſtile P Z 38 d. 28′.



North Diall.

houre lines of 5 and 7 beyond the center alſo, ſo have you as many as need. The ſtile is the triangle A B C making an angle of 38 d. 28′ the very ſame that was for the South Diall, and is repreſented by the prickt lines, wherein the ſide C B is the ſubſtile or line of midnight, A B muſt ſtand horizontally, the center C downwards, that the line C A repreſenting the axis may point upwards to the North pole, and the whole ſtile C B A ſtand perpendicular to the line C B, ſo have you done what was deſired.

 CHAP.

CHAP. IX.

To draw the houre lines upon a direct East or West plane.

AS the planes of South and North Dials lie in the azimuth of East and West, and their poles in the South and North parts of the meridian, so do the planes of East and West Dials lie in the South and North azimuth, and their poles in the East and West part of the horizon, from whence these Dials, (as all the rest) receive their denomination.

Now because the meridian, in which this plane lieth, is one of the houre circles, and no plane that lieth in any of the houre circles (as doth the horizontall of a right sphere, the East and West, and equinoctiall planes of an oblique sphere) doth cut the axis of the world, but is paralell thereto, therefore the houre lines of all these kinde of planes are also paralell each to other, and may be represented in the schem of the sixt Chapter, after this manner.

The Demonstration.

Let N E S W in this case be supposed to bee the equinoctiall divided into 24 equall parts, and let the prickt line 8 E 2, paralell to N Z S, be a tangent line to that circle in E, streight lines drawn from the center Z thorow the equall divisions of the limb, intersecting the tangent line, shall give points in 4, 5, 6, 7, 8, 9, 10, 11, thorow which paralels being drawn to the prime verticall, or 6 of clock houre line E Z W, you have the houre lines desired, which may for more certainties sake bee found by tangents also; for making Z E of the former schem, the Radius, and 8 E 2, continuing the tangent line as aforesayd, let the sector be opened to the width of Z E, (or for want thereof use the scale A 10, B 10, of the first Chapter) then shall the naturall tangent of 15 d. $\underline{268}$, and of 30 d. $\underline{577}$, and of 45 d. $\underline{1000}$ (equall to the Radius &c.) taken thereof, and set both wayes from E upon the tangent line 8 E 2, give the distance of the

houres

oures of 5 and 7, 4 and 8, 3 and 9 &c. from the 6 of clock oure, as aforesayd.

The Arithmeticall operation.

Make therefore the table for the houre distances, as in the xample adjoyning. First set down the houres and parts, beginng with 4 and 8 the extream houres of the East and West Dials, 5 and 7, 6 and 6, and so proceeding to 12, unto these houres and parts set the equinoctiall distances from 6 of clock each way, (which being perpendicular to the plane, is here instead of the substile line) *vizt.* for 4 and 8, 30 d, for 5 and 7, 15 d, for 7 and 5 againe 15 d, for 9 and 3, 45 d, and so of the rest, unto these distances adjoyn the naturall tangents, *vizt.* of 15 d. 268, of 30 d. 577, of 45 d. 1000, &c. as you see in the example, so is the table fitted for use, and is generall for all latitudes whatsoever.

Houres and Halves.		Equinoctiall distances.	Naturall tangents or houre dist. upon the plane	Houres and Halves.		Equinoctiall distances.	Naturall tangents & houre dist. upon the plane
4	8	30d.0'	577	8	4	30d.0	577
	½	22.30	414		½	37.30	767
5	7	15.0	268	9	3	45.0	1000
	½	7.30	132		½	52.30	1303
6	6	Subst.	*	10	2	60.0	1732
	½	7.30	132		½	67.30	2414
7	5	15.0	268	11	1	75.0	3732
	½	22.30	414		½	82.30	7596
				12		Infinite	

The Geometricall projection.

Proceed then to make the Diall, and first draw the horizontall line B A C, at your pleasure, upon any part thereof, as at A make two obscure arches, D B G, and F C E, the extent of 60d. of the chord, of the same chord take 38 d. 28', the heighth of the

equator,

equator, which ſet from B to D, & from C to E, alſo take ther of 5 1 d. 32′, the heighth of the pole, and ſet it from B to G, an from C to F, draw the ſtreight lines D A E repreſenting the quinoctiall, as by the angle B A D 38 d. 28′, which the horizo and equator make, and F A G repreſenting the axis of th world, as by the angle F A C 5 1 d. 32′, which the pole and ho rizon make, is manifeſt, & this will be alſo the *6* of clock houre or ſubſtile of this Diall, ſeeing the plane it ſelfe lieth in the me ridian *90* d. diſtant from the ſame ; now becauſe the apex o top of the ſtile A L (equall to the diſtance of the houres of 3 o *9* from *6*) doth give the ſhadow in all planes that are paralell t the axis, it will be neceſſary to proportion the ſtile to the plane that the houre lines may be enlarged or contracted according t the length of the ſame, which is done in this manner ; Let th place of the ſtile at A, and the place of the extream houre at ♈ or K (in the Eaſt Diall 1 1, in the Weſt 1 of clock) 75 d. diſtan upon the equator from A be given in ſome known parts, whic will be more or leſſe according to the greatneſſe of the plane ſuppoſe 348, that is 3 inches and 48 hundred parts, *by the ſecon caſe of R. P. triangles.*

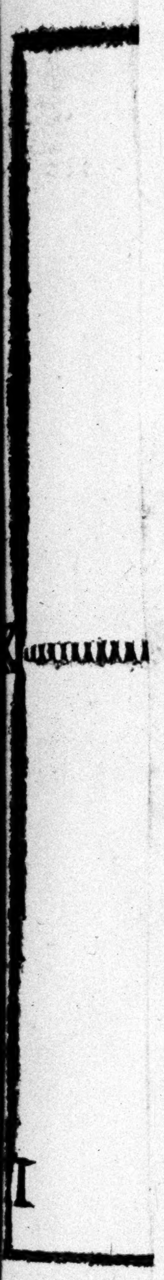
		Logar.	
As the ſine of A L ♈	75 d. 0′	+ 0015.0562	*Arith. compl*
Is to the line A ♈	348	+ 0541.5792	
So is the ſine of A ♈ L	15 d. 0′	+ 9412.9962	
To the line A L	093	— 9969.6316	
		Compl. 0.	

Or by the Chiliads alone for want of a canon.

As the naturall ſine of	75 d. 96593	+ 5015.0544
Is to the line A ♈	348	+ 0541.5793
So is the naturall ſine of	15 d. 25882	+ 4412.9978
To the line A L	0:9	— 9969.6315
		Compl. 0.

Or by the ſame caſe you may alſo ſay,

As the Radius ♈ A
Is to A L the tangent of 15 d.
So is the line ♈ A
To the line A L in the ſame parts.

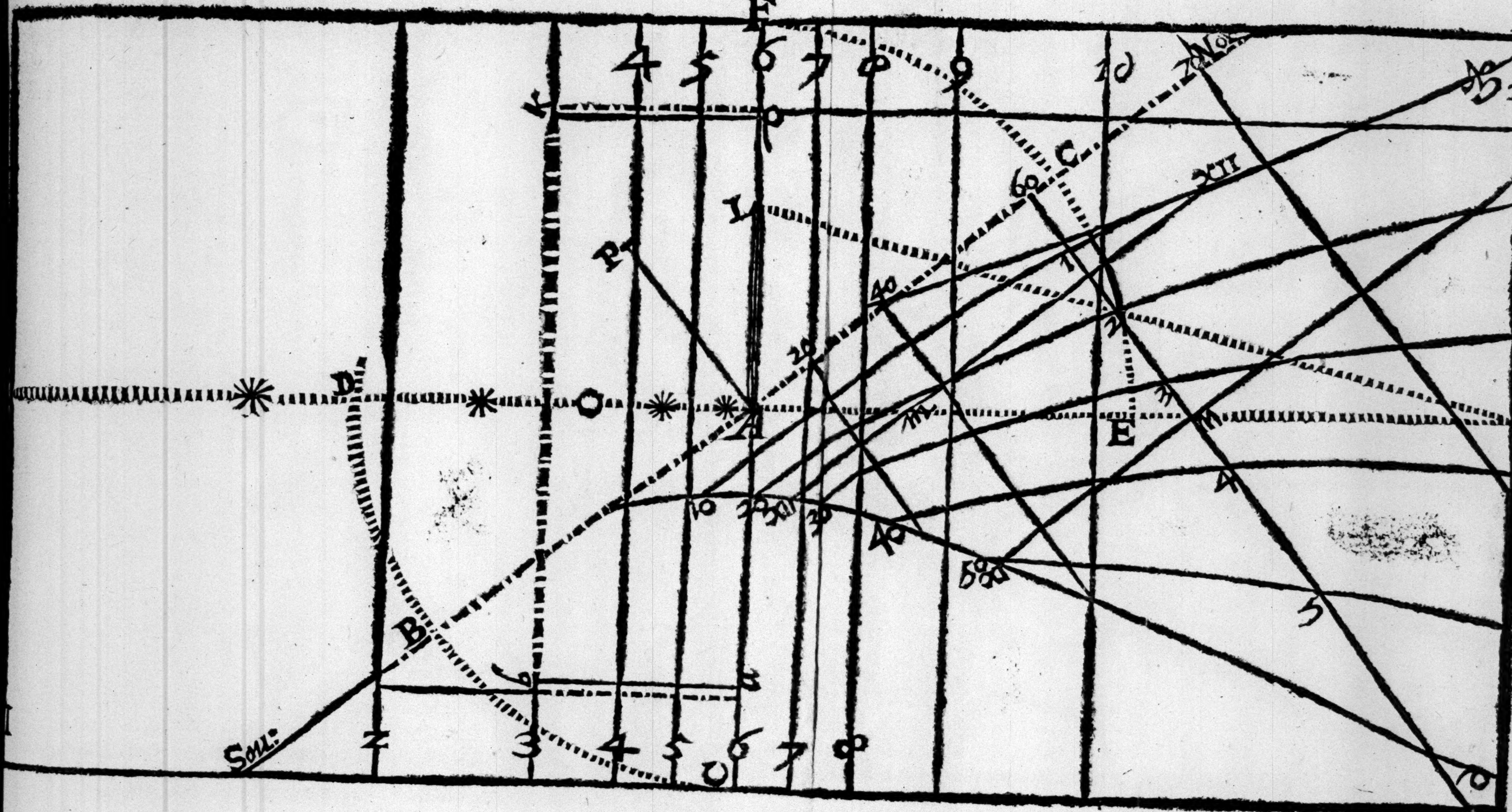


To the length of the stile in known parts.

Wherefore adde the naturall tangent of 4 of clock 577, and the naturall tangent of 11 clock 3712 together, the length of the whole line 4 ♈, or 8 K, the two extream houres, will bee 4309 that is 4 times the Radius and nere 31 hundred parts, by this summe divide the Radius 1000000, encreased with as many ci-

phers

The East Diall.



The West Diall.

Place this folio 98.

The length of the stile A L proportionall to the plane being thus found by the Chiliads alone, (as in like cases may be done) or by the Canon and Chiliads together, to be 093 centesmes of an inch, make that the Radius, then shall the equator K A ♈ be a tangent line thereunto, and the distance of the houre lines of 5 and 7 each way from A upon that line shall be the naturall tangent of 15 d, which is 268 parts, the distance of 8 and 4 the naturall tangent of 30 d. 577 parts, the distance of 9 and 3 (equall to the Radius) the naturall tangent of 45 d. 1000 parts, the distance of 10 and 2 the naturall tangent of 60 d. 1732, and the distance of 11 and 1 the naturall tangent of 75 d. 3732, as in the table doth appeare: Wherefore open the sector to the length of AL, or divide a line equall thereto (as in the first Chapter) from either of which take off these distances, which set both wayes from A will afford you points in the equator ♈AK, thorow which streight lines being drawn paralell to the 6 of clock houre, you have at one work made both the East & West Dials, as in the tipe appeareth, only remember that because the Sun riseth before 4 in ♋, and setteth after 8, you must adde two houres before 6 in the East Diall, and two houres after 6 in the West Diall, that the plane may containe as many houres as it is capable of.

Againe, for varietity sake, or haply you have not a line divided into 100 parts of an inch, you may without resolving a triangle, or giving the length of the plane in known parts, finde the length of the stile proportionall thereto, which being made the Radius, shall justly fill the plane with any two extream houres assigned whatsoever. For,

As the naturall tangents of the two extream houres added together,
Are to the length of the plane in unknown parts,
So is the Radius,
To the length of the stile in known parts.

Wherefore adde the naturall tangent of 4 of clock 577, and the naturall tangent of 11 clock 3732 together, the length of the whole line 4 ♈, or 8 K, the two extream houres, will bee 4309 that is 4 times the Radius and nere 31 hundred parts, by this summe divide the Radius 1000000, encreased with as many ciphers

phers as you think good, the quotient will be 232 the length
the stile A L, as in the example appeareth,

4309

1000000 (232
8618

13820
12927

8930
8618

312

Yet also by Logar. this work is facilitated, for if you take th
Arith. complement of the Logar. of 4309 (neglecting the cha
racterisk) which is 0365 . 6235. and seeke that in the Ch
liads with the characterisk of 2, 3, or 4, you shall finde 232 th
number answerable to your desire. Wherefore open the secto
to the length of 4 ♈, supposed to bee the capacity of the plan
(or divide a line equall thereto, as in the first Chapter) and tak
thereof 232 parts for the length of the stile A L, make that th
Radius, and the naturall tangents of the houre distances in th
table shall justly fill the plane.

The houre lines being thus drawn, the stile may bee eithe
a streight pin like A L, fixed in the center A at right angles t
the plane, shewing the houres with the top thereof, or else a
oblong like unto a b c d, of equall heighth to A L, erected pe
pendicularly over the houre line 6 A 6, and shewing the houre
with the upper edge thereof; let B A C bee horizontall, B re
specting the South, and C the North, then will ♈ A K point u
to the equinoctiall, and 6 A 6 to the pole, and the Diall stand i
its due position, to receive the shadow of either of the stiles a
foresayd.

The West Diall is the same in all respects with the East,
appeareth by the making of them, only the arch BD the height
of the equator above the horizon must bee drawn on the righ
hand of the center A for the West Diall, as here it was on th
le

left hand for the East Diall, (and as the equinoctiall it selfe lieth from you in the heavens, your face being turned to the plane) that so the houre lines crossing it at right angles, may respect the poles of the world, unto which they are paralell.

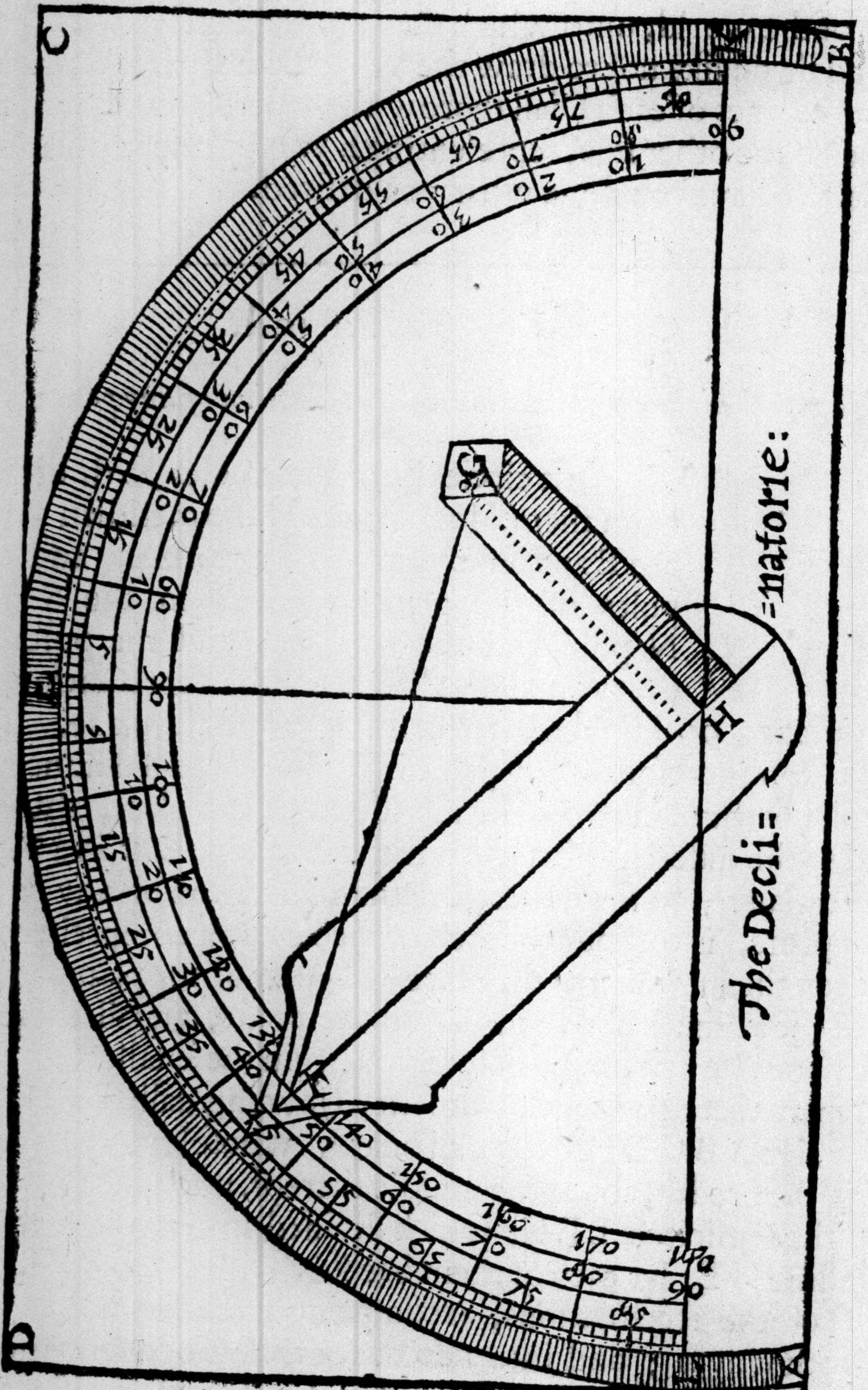
And if you like not to draw the West Diall by it selfe, prick the houre lines of each Diall thorow the paper, and draw them againe on the other side, representing a West plane, as this doth the East, so have you done what you desired.

CHAP. X. The first part.

How to finde the declination and reclination of any plane.

ALL great circles have their poles 90 d. distant from them, so the poles of the meridian lie in the E and W points of the horizon, and the poles of the prime verticall in the S and N points of the horizon, and the poles of every intermediat azimuth, representing so many planes, 90 d. in the horizon distant from the plane. The declination therefore of any plane is the horizontall distance of the poles of the plane from the meridian of the place, alwayes equall to the difference between the azimuth of East and West and the plane; to finde therefore the declination of any wall, flat or plane, is to finde the arch of the horizon comprehended between the meridian of the place and poles of the plane, or between the azimuth of E and W and the plane, equall thereto, which must be first found before you begin the Diall.

Prepare therefore the instrument adjoyning called a Declinatory, let A B C D be a squared board, whose length may bee double the bredth, about the middle thereof, upon the center H draw the semicircle L E K, which divided into two quadrants by the line H E, let each of them bee subdivided into 90 d. for the use of the Reclinations, accompting from the middle line E H both wayes; and into 180 d. for the use of declinations, accounting from the diameter L B. Let the moveable lable G F H turne upon the center H, and let the perpendicular H G be


The Decli=
=natorie:

be erected at right angles to the line of the lable F H from the top of the perpendicular G to the end of the lable at F make fast a small thred, whose shadow upon the line F H G shall direct the true position of the lable.

Vpon the backside of the same draw another semicircle concentrick with the former, which divided into two quadrants, each quadrant into 90 d. accounting the first degree from the diameter A B, close under the periphery so divided make a hollow grooue (like the black circle) of such capacity that a small bullet hanging by a thred from the center, may play at liberty therein, by application of the side D C unto any reclining, and the side A B unto any inclining plane, the thred on the backside of the instrument doth intersect the degree of reclination and inclination, accounting from the diameter A B, without any more trouble, which being plaine and common in use, I leave to practice without further directions, only remembring that if the board be large enough to receive concentrick circles with diagonals, the work proceeding to parts is the more perfect.

But for want of such an instrument, you may with great ease by crossing two rulers at right angles, the one paralell to the horizontall line, the other to the verticall line of the plane, give the reclination desired.

The Sunne shineth upon all planes declining East before 6 of clock in the morning; if after 6, the plane declineth West; upon South declining how far soever it shineth at twelve: if not, the plane declineth North.

There are many wayes to attaine this declination; the plainest is by a Needle; but because we have lately found a motion in the variation, and the Needle it selfe is so apt by every magneticall attraction to be drawn out of his proper place, and thereby gives a false declination, I omit that as very uncertaine: the best way and least subiect to error is by comparing the azimuth of the Sunne and plane together, from whence wee may artificially argue the true declination thereof.

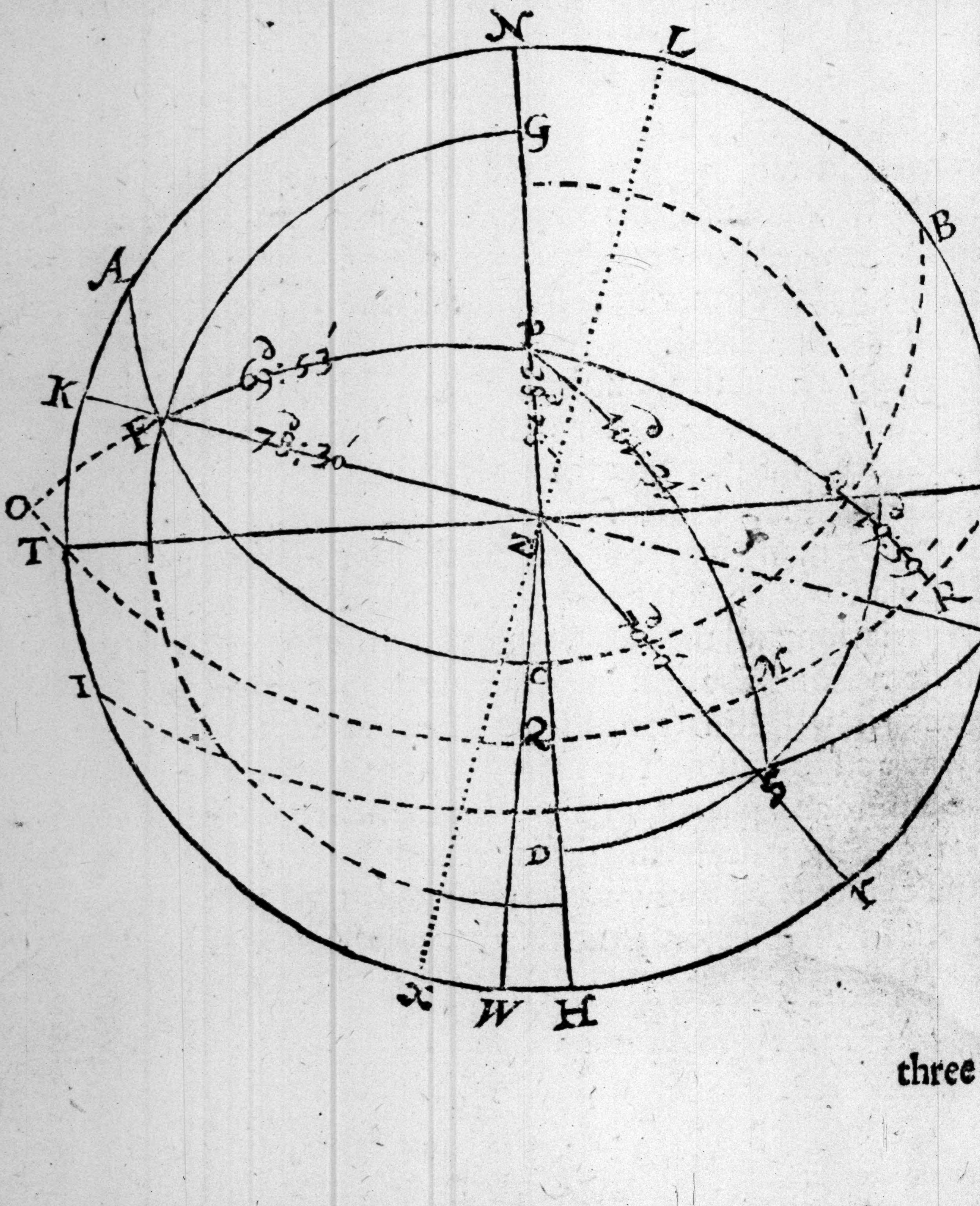
And this may be three wayes practised, two particular onlyusefull in their seasons, the third generall for all times whatsoever.

The

The first way.

The first particular way is in use but from March till Septem-
ber, during the time that the Sunne continueth in the Northe-
part of the eclyptick, and is thus.

First by the declination of the Sunne and the elevation of t-
pole given, finde out the heighth of the Sunne upon the East
West azimuth, and if you will the houre also, that you ne-
not wayt too long: In the diagram following N T H V repr-
senteth the horizon, N P Z H the meridian, T Z V the prim-
verticall, A C B and I S two paralels of the Sunne, T Q V t-
equator, P F, P E, and P S three meridians, Z F, Z *r*, and Z W



three

three azimuths, G F, and D S two almicanters, P the pole of the world, and Z the zenith. From P let fall a quadrant, passing by the place of the Sunne in E, and cutting the equinoctiall at right angles in R; R E is the declination of the Sunne, and V E the heighth of the Sunne upon the prime verticall, and R V the houre reckoned from 6 of clock, or the complement thereof R Q from 12, the things desired, which you may finde either by the small triangle E R V, or by his verticall P Z E, or by the quadrantall Z Q V. Let the declination of the Sunne R E be given on the tenth of May 1622, about 7 of clock in the morning, 19 d. 59′, and the elevation of the pole P N, equall to Z Q, 51 d. 32′, to finde out E V the heighth of the Sunne, *by the first variety of the eighth case of R. S. Triangles. For,*

		Logar.
As the sine of Z Q the latitude of the place	51^{d}.32′	9893.74
Is to the sine of E R the declination of the Sunne,	19 59	9533.70
So is the whole sine Z V	90 0	10000.00
To the sine of E V the heighth of the Sunne desired,	25 53	9639.96

And for the houre in the same Triangle, by the first variety of the fourth case of R. S. triangles.

As the tangent of Q Z	51^{d}.32′	10099.91
Is to the tangent of R E	19 59	9560.67
So is the whole sine Q V	90 0	10000.00
To the sine of R V	16 48	9460.76

Which 16 d. 48′ resolved into time (by allowing 15 d. to an houre, and 15′ of a degree to one minute of time) giveth one houre, seven minutes, before or after 6 of clock, according to the time of observation in the morning or evening.

The heighth being found, set a quadrant fitted with sights to that heighth, and observe till the Sunne commeth to it, at the same instant apply the side A B of the Declinatory or semicircle foresayd unto the plane horizontally supposed to be x L, turne

the labell to the Sunne till the ſhadow of the thred F G ſtrike juſt upon the line of the labell F H, ſuppoſed to ſtand at V, the prime verticall, then reckon the degrees contayned between the middle line of the ſemicircle E H, ſuppoſed at Y, and the end of the labell at V; the degrees between Y V, the pole of the plane and labell ſtanding upon the prime verticall, are the complement of the declination, and between V L the labell and the plane, the declination it ſelfe. For ſeeing that the middle line of the ſemicircle repreſenteth the pole of the plane at Y, if the plane do not decline, it muſt needs fall out, that the labell turned to the Sunne upon the verticall of Eaſt and Weſt, ſhall juſtly fall upon the middle line of the ſemicircle E H, and ſo Z Y, and Z V in the ſchem become both one, the plane not declining at all, but if (obſerving in the morning) the labell turned to the Sunne upon the prime verticall doth fall between E and A of the ſemicircle, equall to Y L of the ſchem, as at V, then is the plane a South declining Eaſt ſo many degr. as are contayned between V & L the labell and the plane, equall to H Y the meridian and pole of the plane; if it fall between E B the other quadrant of the ſemicircle, equall to *x* Y, then is the plane a North declining East as much. The like may be ſayd for evening obſervation, but contrary; for if the labell turned to the Sunne fall between E and B of the ſemicircle, then is the plane a North declining Weſt, if between E and A, a South declining Weſt as much.

The ſecond way.

The ſecond way is more generall, and altogether as eaſie, but ſomewhat too particular for the time, and that is by attending till the Sunne comes into the paralell of the plane, for then it is in the ſame azimuth with the plane, and the azimuth of the Sun found by his altitude is the true declination of the plane.

Firſt therefore apply the aforeſayd ſemicircle horizontally to the declining plane, ſuppoſed to bee K Z Y, then turne the triangular labell into the diameter thereof L H K, paralell to the ſide A B, attend till the Sunne ſhadowes juſt upon the line, and then take his heighth, by the heighth and declination you have an oblique triangle framed in the diagram adjoyning P F Z, the

three

three sides whereof are given, to finde the angle at Z, *by the first case of O. S. triangles*; for P Z is the complement of P N the heighth of the pole, and Z F the complement of F K the heighth of the Sunne, and F P the complement of O F the declination of the Sunne, by which I seek the angle P Z F, the azimuth of the Sunne and plane.

Example, the tenth of May 1622, let O F the declination about 6 $\frac{1}{2}$ at night be 20 d. 7′, and K F the heighth of the Sunne (about the same time) be 11 d. 30′, to finde the angle Z, *by the first case of O. S. triangles.*

The base	*P F*	69^d	53′		
The sides	*Z F*	78	30		
	Z P	38	28		
The summe		186	51	Logar.	
The halfe		93	25 $\frac{1}{2}$	0000.7764	*Arith. compl.*
Differ. base		23	32 $\frac{1}{2}$	0398.5747	
Differ. sides		14	55 $\frac{1}{2}$	9410.8690	
		54	57 $\frac{1}{2}$	9913.1432	
			Tot.	19723.3633	

Whereof the halfe 9861.6816 *Is the tangent of halfe the angle Z from the North,* 36 *d.* 1′ 35″, *and the cotangent of halfe the angle from the South,* 53 *d.* 58′ 25″.

Which doubled 72 d. 3′ 10″ is the whole angle N Z K from the North, or the complement thereof 107 d. 56′ 50″ the angle H Z K from the South, both of the Sunne and plane, therefore the azimuth Z F K, under which this plane lieth, representeth the true situation thereof, declining from T the West point of the horizon the angle T Z K 17 d. 57′ *fere*, the complement of N Z K equall to the true declination N L or x H reckoned from the meridian N Z H, to the poles of the plane x L, 90 d. distant from the plane K Z Y, and is a South declining West 17 d. 57′, or North declining East as much, because the poles of the plane x and L fall between the South and West, and North and East parts of the horizon, as by the schem appeareth.

The third way.

The third way by azimuths is generall for all times of the da
and of the yeere, but best when the Sunne is not too high, an
hath little refraction. Whensoever you would therefore find
the declination of any wall or plane this way, first take th
heighth of the Sunne, at the same instant apply the semicircle
the plane horizontally, which now suppose to bee *x* Z L, turn
the triangular labell to the Sunne, and reckon the degrees con
tayned between the plane and the labell, which wee may ca
the azimuth of the plane, (in South planes from the South par
in North from the North part of the plane) which note. The
must you (by the like oblique triangle as before) calculate the a
zimuth of the Sunne, by these two azimuths compared togethe
the declination is thus found.

If the labell turned to the Sunne fall just upon the midd
line of the semicircle, representing the pole of the plane, the
is the azimuth of the Sunne counted from the South or Nort
points of the meridian respectively, the declination of th
plane, Easterly or Westerly according to the time of observat
on; but if the azimuth of the plane *x* Z L, declining East, b
x Z V, 107 d. 57′, and the azimuth of the Sunne H V 90 d. ta
H V out of *x* V, there resteth *x* H 17 d. 57′, the compleme
whereof to 90 d. is H Y, 72 d. 3′, the declination desired. I
the azimuth of the plane bee *x* Z *r* 54 d. 44′, and of the Sunn
H Z *r* 36 d. 47′, take H R out of *x* R, there resteth H *x* 17 d
57′, therefore H Y 72 d. 3′ as afore. Lastly, if the azimuth o
the plane be *x* Z W 10 d. and of the Sunne W Z H 7 d. 57
adde both together, so have you *x* H 17 d. 57′, therefore also
H Y 72 d. 3′, as afore. Againe, if the azimuth of the plane KZY
declining West, be K Z *r* 144 d. 44′, and the azimuth of the
Sunne H Z *r* 36 d. 47′, take H *r* out of K *r*, there resteth K H
107 d. 57, from whence subtract K *x* 90 d, there resteth *x* H
17 d. 57′, the declination desired. If the azimuth of the plane
be K Z W, and of the Sunne W H, adde them together, so have
you K H, from which subtract K *x* 90 d. the rest is *x* H, the de-
clination as afore. Lastly, if the azimuth of the plane bee K T,

and

[an]d the azimuth of the Sunne T H, adde K T and T H together, [so h]ave you K H, out of which subtract K *x* 90 d. so have you [x H] 17 d. 57', the declination as afore.

[N]ote that all these wayes may for necessity bee practised with a [squ]are board and plumline, without any divisions at all, the angle [bei]ng taken off from a chord.

Example, in the triangle Z P S, let *r* S the heighth of the Sun [bef]ore noone be 20 d. 0', therefore the complement thereof Z S [70] d. 0', the declination of the Sunne Southward S M 11 d. 30', [wh]ich added to M P 90 d. maketh the whole side P S 101 d. 31' as before, the complement of the heighth of the pole 38 d. and I seek the angle P Z S, the azimuth of the Sunne, *by the Case of O. S. triangles.*

[T]he base P S	101 d.	33'	30"		
[T]he sides Z S	70	0	0		
[T]he sides Z P	38	28	0		
[T]he summe	210	1	30		
[T]he halfe	105	0	45	0015.0817	*Arith. compl.*
[Diff.] of the base	3	27	15	1220.0324	*Arith. compl.*
[Diff.] of the sides	35	0	45	9758.7265	
[Diff.] of the sides	66	32	45	9962.5486	
			Totall	20959.3992	

Whereof the halfe 10478.1996 *Is the Logar. of the tangent of halfe the angle Z, from the North* 71 *d.* 36'. 27", *and the cotangent of halfe the angle from the South* 18 *d.* 23', 33.

Therefore the double 36 d. 47' is the whole angle H Z *r* from H the South part of the meridian, Easterly to *r*, or the complement thereof to 180 d. *vizt.* 143 d. 13', is the angle or azimuth of the Sun *r* Z N, from N, the North part of the meridian to *r*, the thing desired.

Now suppose the azimuth of the plane found by the semicircle as afore, to be at the same time *x r* 54 d. 44', subtract the azimuth of the Sunne H *r* 36 d. 47', out of the azimuth of the plane *x r* 54 d. 44', there resteth *x* H 17 d. 57', the difference

 between

The third way.

The third way by azimuths is generall for all times of the d and of the yeere, but best when the Sunne is not too high, a hath little refraction. Whensoever you would therefore fin the declination of any wall or plane this way, first take t heighth of the Sunne, at the same instant apply the semicircle the plane horizontally, which now suppose to bee *x* Z L, tu the triangular labell to the Sunne, and reckon the degrees c tayned between the plane and the labell, which wee may the azimuth of the plane, (in South planes from the South p in North from the North part of the plane) which note. T must you (by the like oblique triangle as before) calculate th zimuth of the Sunne, by these two azimuths compared toget the declination is thus found.

If the labell turned to the Sunne fall just upon the mi line of the semicircle, representing the pole of the plane, t is the azimuth of the Sunne counted from the South or N points of the meridian respectively, the declination of plane, Easterly or Westerly according to the time of obser on; but if the azimuth of the plane *x* Z L, declining East, *x* Z V, 107 d. 57′, and the azimuth of the Sunne H V 90 d. H V out of *x* V, there resteth *x* H 17 d. 57′, the complen whereof to 90 d. is H Y, 72 d. 3′, the declination desired. the azimuth of the plane bee *x* Z *r* 54 d. 44′, and of the Sunne H Z *r* 36 d. 47′, take H R out of *x* R, there resteth H *x* 17 d. 57′, therefore H Y 72 d. 3′ as afore. Lastly, if the azimuth of the plane be *x* Z W 10 d. and of the Sunne W Z H 7 d. 57′, adde both together, so have you *x* H 17 d. 57′, therefore also H Y 72 d. 3′, as afore. Againe, if the azimuth of the plane KZY declining West, be K Z *r* 144 d. 44′, and the azimuth of the Sunne H Z *r* 36 d. 47′, take H *r* out of K *r*, there resteth K H 107 d. 57, from whence subtract K *x* 90 d, there resteth *x* H 17 d. 57′, the declination desired. If the azimuth of the plane be K Z W, and of the Sunne W H, adde them together, so have you K H, from which subtract K *x* 90 d. the rest is *x* H, the declination as afore. Lastly, if the azimuth of the plane bee K T and

and the azimuth of the Sunne T H, adde K T and T H together, so have you K H, out of which subtract K x 90 d. so have you x H, 17 d. 57', the declination as afore.

Note that all these wayes may for necessity bee practised with a square board and plumline, without any divisions at all, the angle being taken off from a chord.

Example, in the triangle Z P S, let r S the heighth of the Sun before noone be 20 d. 0', therefore the complement thereof Z S 70 d. 0', the declination of the Sunne Southward S M 11 d. 30', which added to M P 90 d. maketh the whole side P S 101 d. 31' Z P as before, the complement of the heighth of the pole 38 d. 28', and I seek the angle P Z S, the azimuth of the Sunne, *by the first Case of O. S. triangles.*

The base P S	101 d. 33'	30"			
The sides Z S	70	0	0		
The sides Z P	38	28	0		
The summe	210	1	30		
The halfe	105	0	45	0015.0817	*Arith. compl.*
Diff. of the base	3	27	15	1220.0324	*Arith. compl.*
Diff. of the sides	35	0	45	9758.7265	
Diff. of the sides	66	32	45	9962.5486	
	Totall			20959.3992	

Whereof the halfe 10478.1996 *Is the Logar. of the tangent of halfe the angle Z, from the North* 71 *d.* 36'. 27", *and the cotangent of halfe the angle from the South* 18 *d.* 23', 33.

Therefore the double 36 d. 47' is the whole angle H Z r from H the South part of the meridian, Easterly to r, or the complement thereof to 180 d. *vizt.* 143 d. 13', is the angle or azimuth of the Sun r Z N, from N, the North part of the meridian to r, the thing desired.

Now suppose the azimuth of the plane found by the semicircle as afore, to be at the same time x r 54 d. 44', subtract the azimuth of the Sunne H r 36 d. 47', out of the azimuth of the plane x r 54 d. 44', there resteth x H 17 d. 57', the difference

between the meridian and the plane, the complement where
to 90 d. is H Y 72 d. 3′, the difference between the meridia
and pole of the plane, the declination desired, as by the definit
on thereof appeareth, and is a South declining East 72 d. 3′,
North declining West as much, because the poles of the plan
K and Y fall between the south and east, or north and west,
in the schem appeareth.

CHAP. X. The second part.

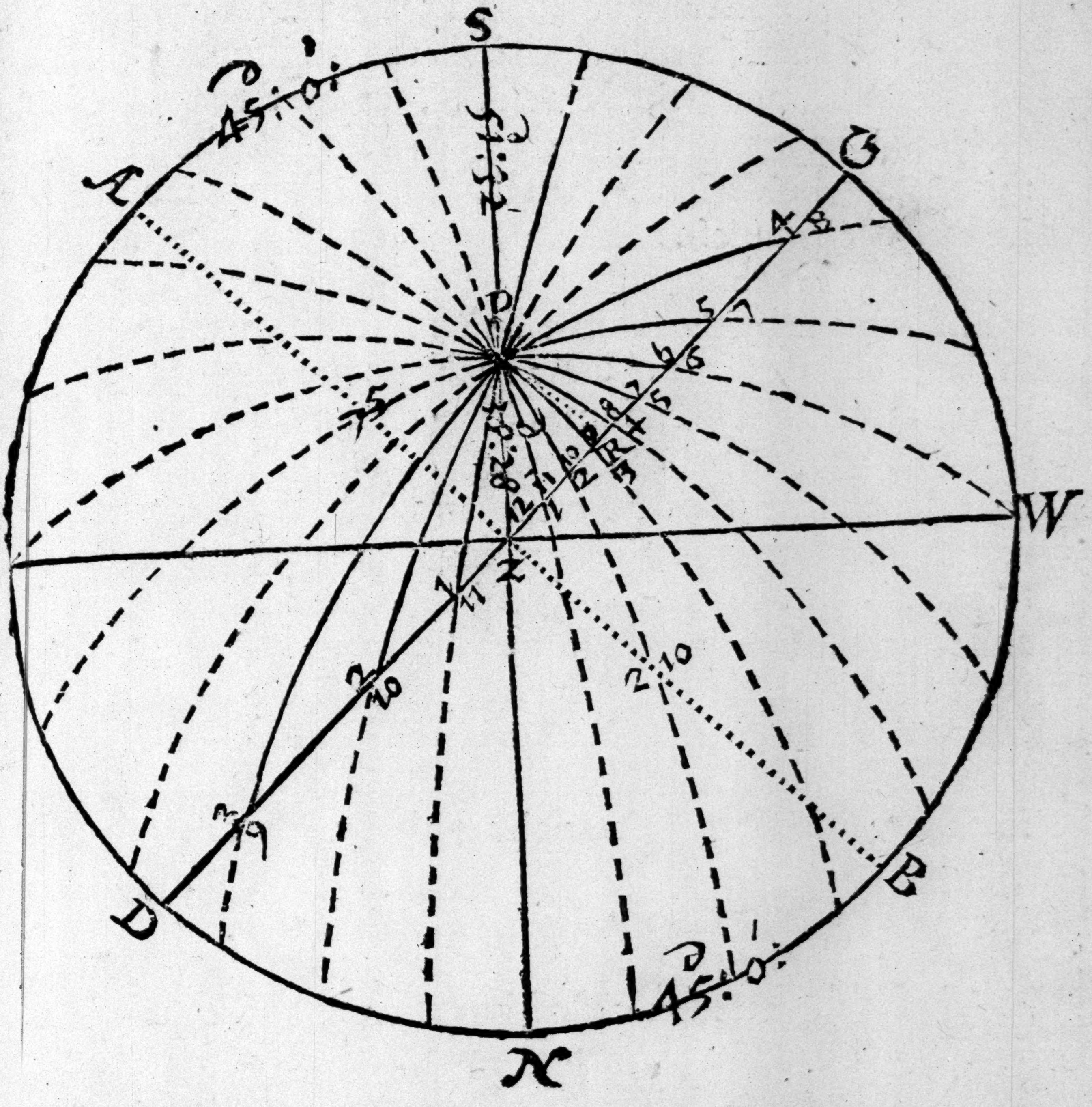
How to draw the houre lines upon a South or North erect plan declining East or West, to any declination given.

EVery erect plane lieth under some azimuth
other; and those only are sayd to decline whi
differ from the meridian and prime verticall.

The Demonstration.

The declination therefore being thus attayned, (or by wh
other meanes you like best) then make the schem by the rul
of the fourth Chapter; (which being inverted is the same, bo
for north and south declination) wherein as before S E N W
the horizon, S P Z N the meridian thereof, S the south part,
the north, E Z W the azimuth of East and West, G Z D t
declining plane, the poles whereof are B and A the declinati
from the south easterly, or north westerly S A, or N B 45 d, a
so much doth the plane D Z G decline from W and E; the W
and East points in the schem, the houre circles drawn, (as b
fore) and proper to this plane, are the black lines passing thoro
the pole P, and crossing upon the plane G Z D, wherein no
generally, that where they runne neerest together, thereabou
must the stile stand, and alwayes on the contrary side to the d
clination, as in this example declining East, it therefore stan
eth on the West side, (supposing P to bee the South pole) b
tween Z and G, the reason whereof doth manifestly appeare.

Fi



First in the ſchem, wherein the plane declining Eaſtwards, the morning houres, together with the ſubſtile P R fall on the Weſt ſide thereof by the work, and contrary: for the houre lines remayning fixed, if you ſuppoſe the axis A Z B, and the plane it ſelfe G Z D, (croſſing each other at right angles) to bee moveable, and turned about upon the center Z, till A Z B come into the place of G Z D, then will the declination be Weſterly, and the plane ſtanding in the place of the axis A Z B, will receive the afternoone houres in the prickt lines, running together on the Eaſt ſide, with the ſame angles that now declining Eaſt, they do on the Weſt ſide thereof. But the true reaſon is drawn from the ſituation of the place, where the plane on which this Diall is made, (wreſted out of the true forme, to ſerve our turne here)

here) would be an horizontall plane, and the ſubſtile in this Diall, the meridian there, which is in the longitude of 51 d. 57′, East from us, and latitude 26 d. 6′, as by the 8 proposition of the 34 Chapter doth appeare. Now becauſe the place where this analogy holdeth, lieth Eaſt from us, the Sunne moving from Eaſt to Weſt, muſt in common reaſon come firſt upon that meridian before it commeth upon ours, which being repreſented upon the plane by the ſubſtile line, muſt therefore bee ſo placed in the Diall, that it may ſhew us the noone of that place three houres, twenty eight minutes ſooner than ours, but the Sunne riſing Eaſt, ſendeth the ſhadow of the axis Weſt, (and alwayes to the oppoſite part of the meridian wherein hee is) wherfore reaſon enforceth, that the morning houres bee put on the Weſt ſide of the meridian, as the evening houres are on the Eaſt ſide, and from the ſame ground, that the ſubſtile of every plane repreſenting the meridian thereof, muſt alwayes ſtand on the contrary ſide to the declination of the plane, and that the houre lines muſt run neereſt together about the ſame, becauſe the Sun in that poſition is at right angles with the plane.

The Arithmeticall calculation.

Theſe things thus enlarged, I now come to the making of the Diall, for the better performing whereof three things muſt bee firſt found; *vizt.*

1 The elevation of the pole above the plane, repreſented by P R, which is the heighth of the ſtile, and is an arch of the meridian of the plane betweene the pole of the world and the plane.

2 The diſtance of the ſubſtile from the meridian, repreſented by Z R, and is an arch of the plane between the meridian and the ſubſtile.

3 The angle Z P R betwixt the two meridians, *vizt.* the ſubſtile P R, the meridian of the plane, and the line P Z N the meridian of the place, and they are thus found.

Becauſe the ſubſtile is the meridian of the plane, it muſt be part of a great circle paſſing thorow the pole of the world, and croſſing the plane at right angles, therefore in the ſuppoſed right angled

angled triangle P R Z, (for yet the place of R is not found) you have the base P Z 38 d. 28′ given, and the angle P Z R the complement of the declination 45 d. and the supposed right angle at R, to finde the side P R, which is the heighth of the stile (as aforesayd) but yet the place of it unknown.

Wherefore by the first variety of the first case of right angled sphericall triangles, I say,

First,			Log.
As the sine of P R Z	90^d.	0′	10000.0000
Is to the sine of the side P Z	38	28	9793.8317
So is the sine of the angle P Z R the compl. of the declinat.	45	0	9849.4851
To the sine of the side P R	26	6	9643.3168

Which 26 d. 6′ is the heighth of the stile above the plane.

Secondly you may finde the distance of the substile from the meridian Z R, by the second variety of the fourth case of R. S. triangles, or the second of the third. For,

Secondly,			Logar.
As the tangent of S G the measure of the angle Z	45^d.	0′	10000.0000
Is to the tangent of P R	26	6	9690.1029
So is the Radius G Z	90	0	10000.0000
To the sine of R Z	29	20	9690.1029

Which 29 d. 20′ is the distance of the substile from the meridian.

These things given, the angle at P between the two meridians is found by the second variety of the 12, 13, 14, or 16 Cases of R. S. triangles. For,

	Thirdly,		Logar.
As the sine of Z P	38^d.	28′	9793.83
Is to the sine of Z R P	90	0	10000.00
So is the sine of Z R	29	20	9690.09
To the sine of Z P R	51	57	9896.26

Having

Having found the angle between the meridians to bee 51 d. 57′, you may conclude from thence, that the substile shall fall between the third [illegible] and fourth houres distance from the meridian of the place, and therefore between 8 and 9 of clock in the morning, because the plane declineth East from us, 9 of clock being 45 d. from the meridian, and 8 of clock 60 d. distant, therefore now let fall a perpendicular between 9 and 8, to enform the fancy in the rest of the work, & this shall make up the triangle before mentioned, & supposed P R Z, which being found, there are 2 wayes to calculate the houres arithmetically. The first by oblique sphericall triangles (the 9 [illegible] Case) requiring two works to every houre, for in the oblique triangle P Z 11, you have the angle at P given, 15 d. in the equator, and the angle at Z given, 45 d. in the horizon, and the side comprehended between them P Z 38 d. 28′ on the meridian, to finde the side Z 11, the first houres distance from the meridian upon the plane, and so must you proceed with all the rest, but this being very tedious, I omit. The second way is both easie and pleasant, the former things being first found, for by help of the angle between the meridians at P and the heighth of the stile P R, you may finde all the houre distances as easily as you did in the South Diall, or if you will every two houres 90 d. distant one from the other, by one subtraction and addition of the same numbers, or by two additions as you did in the horizontall.

And here you may note, that in the former work you finde all the houres from the meridian of the place, but where you use the help of the angle between the meridians, you finde the distance of all the houres from the substile each way, which is the meridian of the plane.

Data,	Elevation of the pole S P	$51^d.32'$	
	South declining East S A	45 . 0	

Quæsita,	Heighth of the stile P R	$26^d.$	$6'$
	Distance of the substile and meridian Z R	29	20
	Angle between the meridians R P Z	51	57

Houres

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	True houre distances	Differ.
9	3	6d.57′	8729.32	3d. 4′	
	½	14.27	9054.41	6.28	3d.24′.
10	2	21.57	9248.63	10. 3	3. 35
	½	29.27	9395.07	13.57	3. 54
11	1	36.57	9519.64	18.18	4. 21
	½	44.27	9634.97	23.20	9. 2
12	12	51.57	9749.72	29.20	6. 00
	½	59.27	09872.30	36.42	7. 22
1	11	66.57	10014.41	45.57	9. 15
	½	74.27	10198.86	57.41	11.44
2	10	81.57	10492.77	72.11	14.30
	½	89.27	11661.06	88.46	16.35

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
	½	0d.33′	7625.57	0d. 15′	
8	4	8. 3	8793.86	3. 34	3d.19′
	½	15.33	9087.77	6. 59	3. 25
7	5	23. 3	9272.22	10.36	3. 37
	½	30.33	9414.33	14. 33	3. 57
6	6	38. 3	9536.90	19. 0	4. 27
	½	45.33	9651.65	24. 9	5. 9
5	7	53. 3	9766.99	30.19	6. 10
	½	60.33	9891.55	37.55	7. 36
4	8	68. 3	10038.00	47.30	9. 35
	½	75.33	10232.22	57.38	12. 8
3	9	83. 3	10557.32	74.31	14.53

Now therefore make a table for the houres distances as formerly you have done, excepting that here you reckon the houres forwards and backwards from the substile, as you did before from the meridian; beginning with 9, 10, 11, 12, 1, 2, on the

one

one ſide; and ſo proceeding with 3, 4, 5, 6, 7, and ending with 8½ on the other ſide; then ſet unto every houre and part the equinoctiall diſtance thereof from the ſubſtile: which is the angle at P, between the ſubſtile and every houre; wherefore for 9 of clock (the diſtance whereof is 45 d. from the meridian), ſubtract 45 d. out of 51 d. 57′, the diſtance of the ſubſtile from the meridian, and there will remaine 6 d. 57′, the diſtance of 9 of clock from the ſubſtile; alſo becauſe 8 of clock is 60 d. diſtant from the meridian, which is more than the diſtance of the ſubſtile, take 51 d. 57′ out of 60 d. there will remaine 8 d. 3′, the diſtance of 8 of clock from the ſubſtile; all the reſt of the houres and parts are eaſily found, by continuall addition of 15 d. for an houre, of 7 d. 30′ for halfe an houre, and of 3 d. 45′ for a quarter, as by the table it ſelfe doth plainly enough appeare. This being prepared, I returne againe to the ſchem, wherein I have the right angled triangle 9 P R to reſolve, therein P R is given the heighth of the ſtile 26 d. 6′, and the angle 9 P R is given as afore, 6 d. 57, and the right angle at R, to finde the ſide 9 R, *by the firſt variety of the fift Caſe of R. S. triangles*. For,

			Logar.
As the ſine of P R Z	90^{d}.	0′	10000.00
Is to the tangent of R P 9	6	57	9085.99
So is the ſine of P R	26	6	9643.32
To the tangent of R 9	3	4	18729.31

Then againe ſubduct the tangent of R P 9 out of the ſine of R P and the Radius, and there ſhall come forth a Logar. tangent 10557.33 the arch whereof is 74 d. 31′ the true houre diſtance of 3 of clock at the ſame work, ~~for 3 of clock~~, which is 90 d. diſtant from 9 of clock.

But if this rule ſeem troubleſome, follow the other, which is both plaine and eaſie, and performes all by addition only: For againe in the ſchem having done with the ſmall triangle R P 9, now work with the complement to 90 d, R P 3, *by the former Caſe of R. S. triangles*, For,

As

			Logar.
As the sine of P R Z	90 d.	0′	10000.00
Is to the tangent of R P 3	83	3	10914.00
So is the sine of P R	26	6	9643.32
To the tangent of R 3	74	31	10557.32

which produces againe the same houres distance as afore.

Now there being no variety in all the rest of the work, but only changing the angle at P, according to every houres distance from the substile, it is needlesse to reiterate the same; therefore transcribe into a paper the Logarith. sine of 26 d. 6′, the heighth of the stile P R, which is 9643.39, for that being continually added unto the Logarith. tangents of every houres equinoctiall distance from the substile, doth beget new Logarith. tangents, whose arches are the true houre distances upon the declining plane G Z D. Thus if you adde to the Logarith. tangent of the 11 houres distance 36 d. 57′, 9876.3 the Logar. sine of P R 9643.39 (which you may do in the booke without writing them down) there will come forth a new Logarith. tangent 19519.64, which giveth the true houre distance for 11 of clock, 18 d. 18′. In the same place remove this Log. sine to the Logarith. tangent of the complement 53 d. 3′, the equinoctiall houre distance of 5 of clock, 90 d. distant from 11, and adde them two together, and you shall produce a new Log. tangent of 19766.99, which gives the true houre distance for 5 of clock 30 d. 19′; and thus you must proceed with all the rest, as you see done in the table aforementioned.

The Geometricall projection.

Having thus easily calculated all the twelve houres at six operations, draw a line paralell to the horizon A C B, crosse it at right angles in C, the lines C O 12 shall be the meridians. Take 60 d. of the chord, and making C the center, draw the semicircle A O B, representing the azimuth G Z D of the schem, in which the plane lieth; upon this circle from O to N set of the distance of the substile from the meridian, which was found before to be 29 d. 20, and that upon the West side of the meridi-

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one ſide; and ſo proceeding with 3, 4, 5, 6, 7, and ending with 8½ on the other ſide; then ſet unto every houre and part the equinoctiall diſtance thereof from the ſubſtile: which is the angle at P, between the ſubſtile and every houre; wherefore for 9 of clock (the diſtance whereof is 45 d. from the meridian) ſubtract 45 d. out of 51 d. 57′, the diſtance of the ſubſtile from the meridian, and there will remaine 6 d. 57′, the diſtance of 9 of clock from the ſubſtile; alſo becauſe 8 of clock is 60 d. diſtant from the meridian, which is more than the diſtance of the ſubſtile, take 51 d. 57′ out of 60 d. there will remaine 8 d. 3′, the diſtance of 8 of clock from the ſubſtile; all the reſt of the houres and parts are eaſily found, by continuall addition of 15 d. for an houre, of 7 d. 30′ for halfe an houre, and of 3 d. 45′ for a quarter, as by the table it ſelfe doth plainly enough appeare. This being prepared, I returne againe to the ſchem, wherein I have the right angled triangle 9 P R to reſolve, therein P R is given the heighth of the ſtile 26 d. 6′, and the angle 9 P R is given as afore, 6 d. 57, and the right angle at R, to finde the ſide 9 R, *by the firſt variety of the fift Caſe of R. S. triangles*. For,

			Logar.
As the ſine of P R Z	90ᵈ.	0′	10000.00
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So is the ſine of P R	26	6	9643.32
To the tangent of R 9	3	4	18729.31

Then againe ſubduct the tangent of R P 9 out of the ſine of R P and the Radius, and there ſhall come forth a Logar. tangent 10557.33 the arch whereof is 74 d. 31′ the true houre diſtance of 3 of clock at the ſame work, ~~for 3 of clock~~, which is 90 d. diſtant from 9 of clock.

But if this rule ſeem troubleſome, follow the other, which is both plaine and eaſie, and performes all by addition only: For againe in the ſchem having done with the ſmall triangle R P 9, now work with the complement to 90 d, R P 3, *by the former Caſe of R. S. triangles*, For,

As

			Logar.
As the sine of P R Z	90 d. 0′		10000.00
Is to the tangent of R P 3	83	3	10914.00
So is the sine of P R	26	6	9643.32
To the tangent of R 3	74	31	10557.32

which produces againe the same houres distance as afore.

Now there being no variety in all the rest of the work, but only changing the angle at P, according to every houres distance from the substile, it is needlesse to reiterate the same; therefore transcribe into a paper the Logarith. sine of 26 d. 6′, the heighth of the stile P R, which is 9643.39, for that being continually added unto the Logarith. tangents of every houres equinoctiall distance from the substile, doth beget new Logarith. tangents, whose arches are the true houre distances upon the declining plane G Z D. Thus if you adde to the Logarith. tangent of the 11 houres distance 36 d. 57′, 9876.3[illegible] the Logar. sine of P R 9643.39 (which you may do in the booke without writing them down) there will come forth a new Logarith. tangent 19519.64, which giveth the true houre distance for 11 of clock, 18 d. 18′. In the same place remove this Log. sine to the Logarith. tangent of the complement 53 d. 3′, the equinoctiall houre distance of 5 of clock, 90 d. distant from 11, and adde them two together, and you shall produce a new Log. tangent of 19766.99, which gives the true houre distance for 5 of clock 30 d. 19′; and thus you must proceed with all the rest, as you see done in the table aforementioned.

The Geometricall projection.

Having thus easily calculated all the twelve houres at six operations, draw a line paralell to the horizon A C B, crosse it at right angles in C, the lines C O 12 shall be the meridians. Take 60 d. of the chord, and making C the center, draw the semicircle A O B, representing the azimuth G Z D of the schem, in which the plane lieth; upon this circle from O to N set of the distance of the substile from the meridian, which was found before to be 29 d. 20, and that upon the West side of the meridi-

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an when the declination is East, on the East side when Westerly. Then take off the same chord the severall houre distances, as they are ready calculated in the table, *vizt.* 10 d 36′ for 7 and 5 of clock, 18 d. 18′ for 11 and 1 of clock, and so of the rest, and set them both wayes from the substile upon the circle R N O as the table it selfe directeth; draw streight lines from the center C to these severall points, so haue you the true houre lines which were desired: Lastly, take off the same chord the height of the stile found to bee 26 d. 6′, which being set from N to R and a streight line drawn from C thorow R, representing the axis, the Diall is finished for use.

In applying it to any wall or plane, let A C B be horizontall, C O perpendicular, and the side or axis of the stile C R pointing to the South pole in South Dials, and to the North pole in North Dials, erected at right angles over the substile line C N so have you fitted a Diall for any South plane declining 45 d. Easterly.

And now you have in this one Diall made foure together, *vizt.* a South declining East and West 45 d. and North declining East and West as much, only placing the numbers of the houres and the stile respectively upon each plane. To make this plainly appeare out of the former schem, suppose that S were againe the North part of the horizon, and P the North pole, and that G Z D were a north declining plane 45 d. West as much as the pole A is from S, then do all the houre circles crosse the same plane as they did the former, only D 2 Z which was in the former the East side and afternoone houres, will now be D 10 Z, the West side and forenoone houres, and so of the rest; the stile also, which in the East declining stood between 9 and 8 of the forenoone houres, will now in the West declining stand between 3 and 4 of the afternoone houres. And lest there should yet be any doubt conceived, I have drawn all the foure Dials aforesayd, wherein you may plainely see that there is no difference at all between the South declining East and the South declining West, but that the forenoon houres on the left hand of the meridian in the East Diall are become the afternoon houres on the right hand of the meridian in the west Diall, and contrary, the stile also of necessity changing the place

with

with the houres for the reasons aforesayd.

And here you may also observe each North Diall framed out of the correspondent South, only drawing the houre lines of the South Diall thorow the center stile and all, *vizt.* the N E out of the S W, and the N W out of the S E, supposing B C D drawn out of the S W Diall, to bee placed upon the N E side of the plane, and B C D drawn out of the S E Diall, to bee placed on the N W side of the plane, according to the true nature and declination of each plane, seeing it followeth of necessity that the South side of the plane declining West, the North side thereof declineth as much East, and contrary, and this also holdeth in the rest of the lineaments belonging to each Diall.

Lastly, one thing more may bee noted, naturally arising out of this schem, which few other will afford, *vizt.* all the foure Dials ready drawn upon it, a good argument to prove the analogy of them, (*mutatis mutandis*) for the South declining East, & the North declining West, are represented by the line G Z D, supposing the one side of it according to the site of the Poles A and B, to respect the North, and the other side the South, as before; and in the very same manner imagine B Z A to bee the declining plane, and G D the poles thereof, then have you S G a south declining west, and N D a north declining East 45 d. and the prickt houre circles, with the very same angles crossing the plane B Z A, as formerly the black lined circles did G Z D, for the houre circles falling from P upon D Z G in the south declining east, and north declining west; as also upon B Z A in the south declining west, and north declining east, have like and equall intersections, as by the bare inspection of the schem doth appeare. From these reasons I conclude, all these kindes of Dials to be but one; and note that in the table I have set the houres of west and east declining together, that it may serve for both turnes, seeing the houre arches upon the planes have the same angles and distances in both. Now because these kindes of Dials are of all other most common in use, and to make them the more conspicuous to every mans eye, they are usually drawn very large, in which case it is convenient to use a rod for the stile instead of a plate; which being made of equall greatnesse, the whole length like a cylinder, the shadow of the upper part

towards

towards the center (in Dials that have centers upon the plane will crosse the houre lines when the shadow of the lower par will not touch the same, and for this cause some do conceive th Diall to bee false made, not considering that the middle of th shadow shewes the true houre, and nether side of the same. T help this, you may make the stile tapering, largest at the lowe end, and so growing lesse towards the center, as the houre line do in the Diall; for seeing the meridians are equidistant in th equator, and the houre lines upon the plane, whether broade or narrower, are equall in time; from the diameter of the grea ter end (which is arbitrary) draw two streight lines, to mee in a point at the length of the stile, so shall it bee proportioned that the shadow may touch the houre lines all at once, yet con sidering that neere the substile a smaller stile will serve the turn whose shadow at the distance of the remotest houre upon th plane will vanish, not making an angle of 30′, it will bee fit t know what must bee the least proportion of the stile, to giv shadow unto all the houre lines of the plane. Suppose therefor an equinoctiall line to bee drawn upon the plane, at what di stance you will from the center, crossing the substile at righ angles, and the houre of 10 produced beyond the plane, as dot the line 1 N 7, in the former Diall, at the distance of N C, 17 parts of an inch, (accounting an inch to a foot.) Next seeke th length of the Radius of this equator N æ in the same parts, *by th first Case of R. P. triangles.*

				Logar.
As the sine of N æ C	90d.	0′		10000.0000
Is to N C	175		+	0243.0380
So is the sine of N C æ	26	6	+	9643.3926
To N æ	7699		—	9886,4306

Charact. Compl. 0.

Therefore the length of N æ is next hand 77 centesmes of a inch, which being the Radius, the equator is a tangent line ther unto, and the distance of the houre of 11 upon the equato shall bee the naturall tangent of 66 d. 57′, and the houre of 1 (the remotest crossing the equator) shall bee the naturall tan gent of 81 d. 57′ 707059, as appeares in the table; and this from

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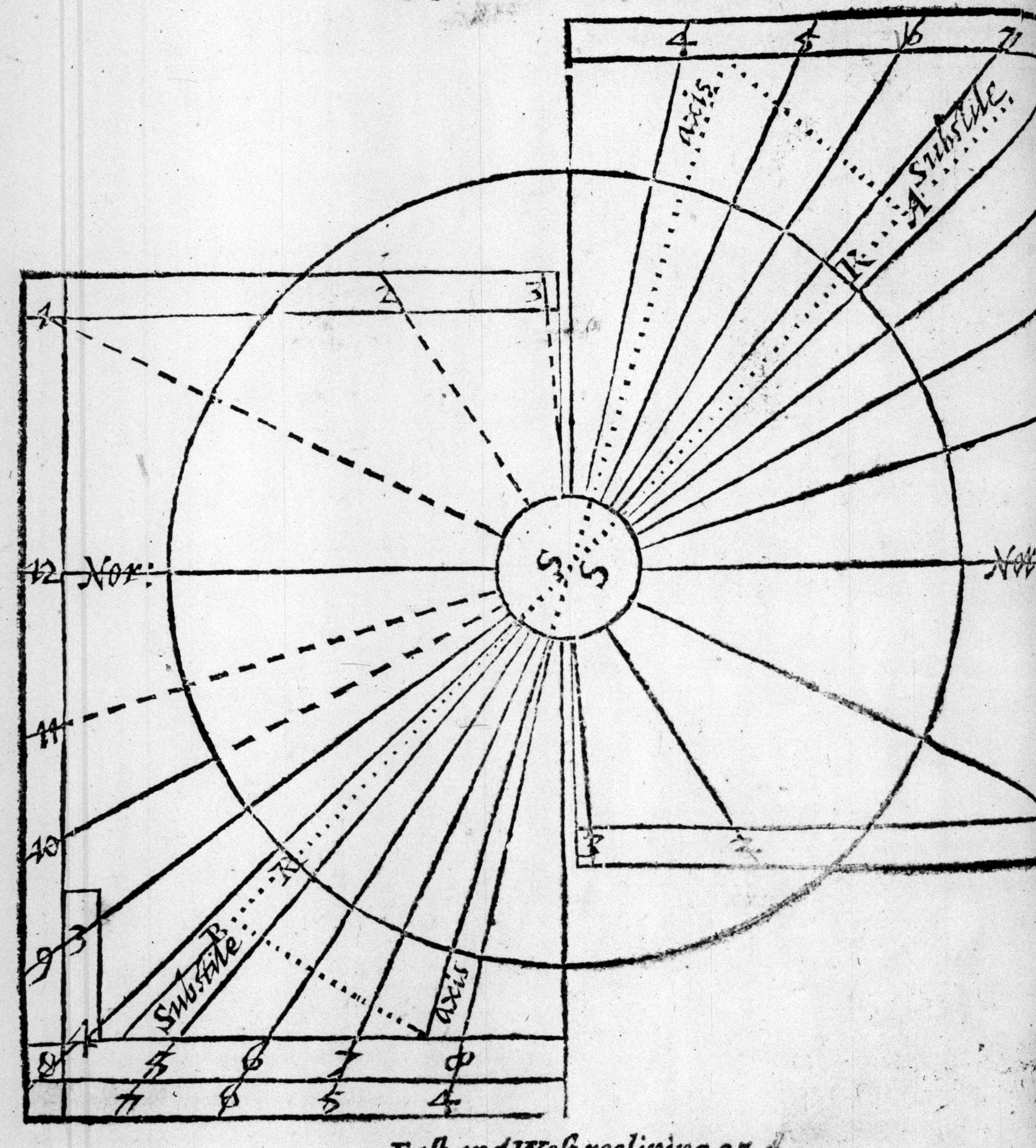
East and West inclining. 35 d.



East and West reclining 35 d.

Place this Folio 221.

the foot of the ſtile, but from the top of the ſtile, which ſerveth our purpoſe, it is the ſecant thereof 714096, wherefore *by the ſecond caſe of R. P. triangles.*

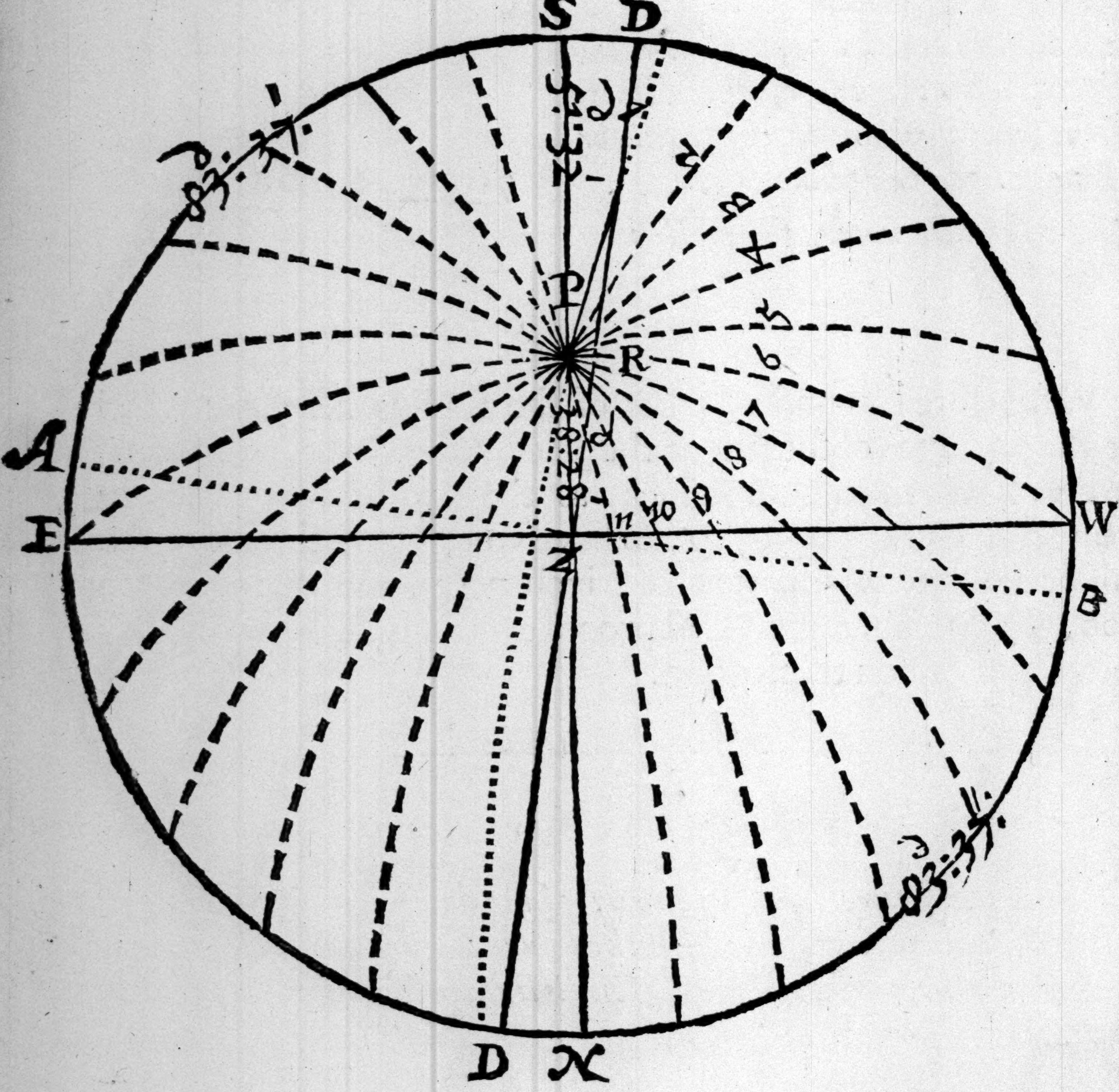
As the Radius, ſuppoſed to be the diſtance from the Sun to the plane . .		10000.0000
Is to the tangent of the ſemidiameter of the Sunne . . .	0° 15′ +	7639.8150
So is the diſtance in parts of the ſecant from the top of the ſtile to the interſection of the equator and x upon the plane . .	714096 +	0853.7566
To the ſemidiameter of the ſtile in like parts	03116 ——	8493.5726
	Compl. Char. 1.	

Wherefore ſix hundred parts of the Radius next hand ſhall be the diameter of the ſtile at the place of the Nodus ; which if you will have in parts of an inch, as the Radius was formerly found, multiply 03116 by 77, ſo have you 02399 therefore the whole diameter 048 parts of an inch next hand divided into 100. And this being the leaſt proportion that can be, you may increaſe it, as you think good.

CHAP. XI.

To draw the houre lines upon any plane declining farre Eaſt or Weſt, or any other, in which the houre lines runne cloſe together, by help of two equinoctiall lines without reſpect to the center.

BEfore I paſſe from declining planes, I think it fit to ſhew the making of thoſe Dyals which by reaſon of their great declination have ſo ſmall elevation of the ſtile, that the houre lines running cloſe together, are of little uſe without ſome other help. Such are many both recliners and declining recliners, but chiefly all


S
D
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those, that decline East or West 80 d. and upwards. In which some of the houre lines are but few minutes asunder, and the neerer the declination is to 90 d. the narrower are the houre lines, as by the schem it selfe and this example following will more plainly appeare. To remedy this, the ordinary way is with a beame compasse of 16, 18, or 20 foot long, upon a large floure to draw the Diall, and then to cut off the houres, stile and all, at 10, 12, or 14 foot distance from the center, as will best fit the plane, but this being too mechanicall for them that have any trigonometricall skill, I omit, and rather commend the way following, by help whereof you may upon halfe a sheet of paper make a perfect modell of your Diall, to what greatnesse you think fit, without regard at all to the center.

The Demonstration.

Suppose therefore that the wall or plane D Z D, on which you would make a Diall, declineth from S to A, that is, from South Easterly 83 d. 37′: Having drawn the schem by the rules of the fourth Chapter, agreable to this declination, (as you see done in this example) set downe the *data*, and by them seeke the *quæsita*.

Data	Elevation of the pole P S . . .	51^{d}.32	
	Declination S A South Easterly . .	83	37
Quæsita	1 Heighth of the stile P R . . .	3	58
	2 Distance of the substile and meridian Z R	38	18
	3 Angle of the meridians Z P R . .	85	0

And you shall finde the heighth of the pole or stile P R above the plane to be 3 d. 58′, *by the first of the first case of R. S. triangles.* The substile from the meridian Z R to be 38 d. 18′, *by the first of the fourth case of R. S. triangles.* And the angle between the meridians Z P R, to be 85 d. 0′ next hand, *by the second of the sixteenth case*; which angle shewes that if the substile were drawn, at the distance of 38 d. 18′ from the meridian, it would fall within five degrees of 6 of clock upon the equator, crossing the substile at right angles.

The first Table for 83^{d} 37'.

Houres and parts.		*Equinoctiall distances.*		*The true houre distances.*		*Naturall tangents.*
4	0	35^{d}	0'	2^{d}	46'	0483
	$\frac{1}{4}$	31	15	2	24	0419
	$\frac{1}{2}$	27	30	2	4	0361
	$\frac{3}{4}$	23	45	1	45	0305
5	0	20	0	1	27	0253
	$\frac{1}{4}$	16	15	1	9	0201
	$\frac{1}{2}$	12	30	0	53	0154
	$\frac{3}{4}$	8	45	0	37	0108
6	0	5	0	0	21	0061
	$\frac{1}{4}$	1	15	0	5	0014
	$\frac{1}{2}$	2	30	0	10	0029
	$\frac{3}{4}$	6	15	0	26	0075
7	0	10	0	0	42	0122
	$\frac{1}{4}$	13	45	0	58	0168
	$\frac{1}{2}$	17	30	1	15	0218
	$\frac{3}{4}$	21	15	1	32	0268
8	0	25	0	1	51	0323
	$\frac{1}{4}$	28	45	2	10	0378
	$\frac{1}{2}$	32	30	2	31	0439
	$\frac{3}{4}$	36	15	2	54	0507
9	0	40	0	3	19	0579
	$\frac{1}{4}$	43	45	3	47	0661
	$\frac{1}{2}$	47	30	4	19	0755
	$\frac{3}{4}$	51	15	4	56	0863
10	0	55	0	5	38	0986
	$\frac{1}{4}$	58	45	6	30	1139
	$\frac{1}{2}$	63	30	7	34	1328
	$\frac{3}{4}$	66	15	8	56	1572
11	0	70	0	10	45	1899
	$\frac{1}{4}$	73	45	13	21	2371
	$\frac{1}{2}$	77	30	17	20	3121
	$\frac{3}{4}$	82	15	24	12	4494
12	0	85	0	38	19	7902

The Arithmeticall calculation.

Now therefore make a table of houres, halfes, and quarters, if you think good, according to the first example, wherein every houres true distance and part, is calculated by the rules of the former Chapter, and necessary if you work from a supposed center, but beginning from the equator, you shall not need to take that paines, the equinoctiall distances alone from the substile, and their naturall tangents (both which are had without trouble of calculation) being altogether sufficient for this turne, as you may see in the second Table. Adjoyne therefore unto each houre and part the equinoctiall distance thereof from the substile, *vizt.* for 6 of clok 5 d. for 5 of clock 20 d. for 7 of clock 10 d. for 8 of clock 25 d. and so of the rest, as you see in the example; and unto them adde the naturall tangents of each houres distance, so is the table prepared for use, by which you may easily frame the Diall to what greatnesse you will after this manner.

The second Table of $83^{d}\ 37'$.

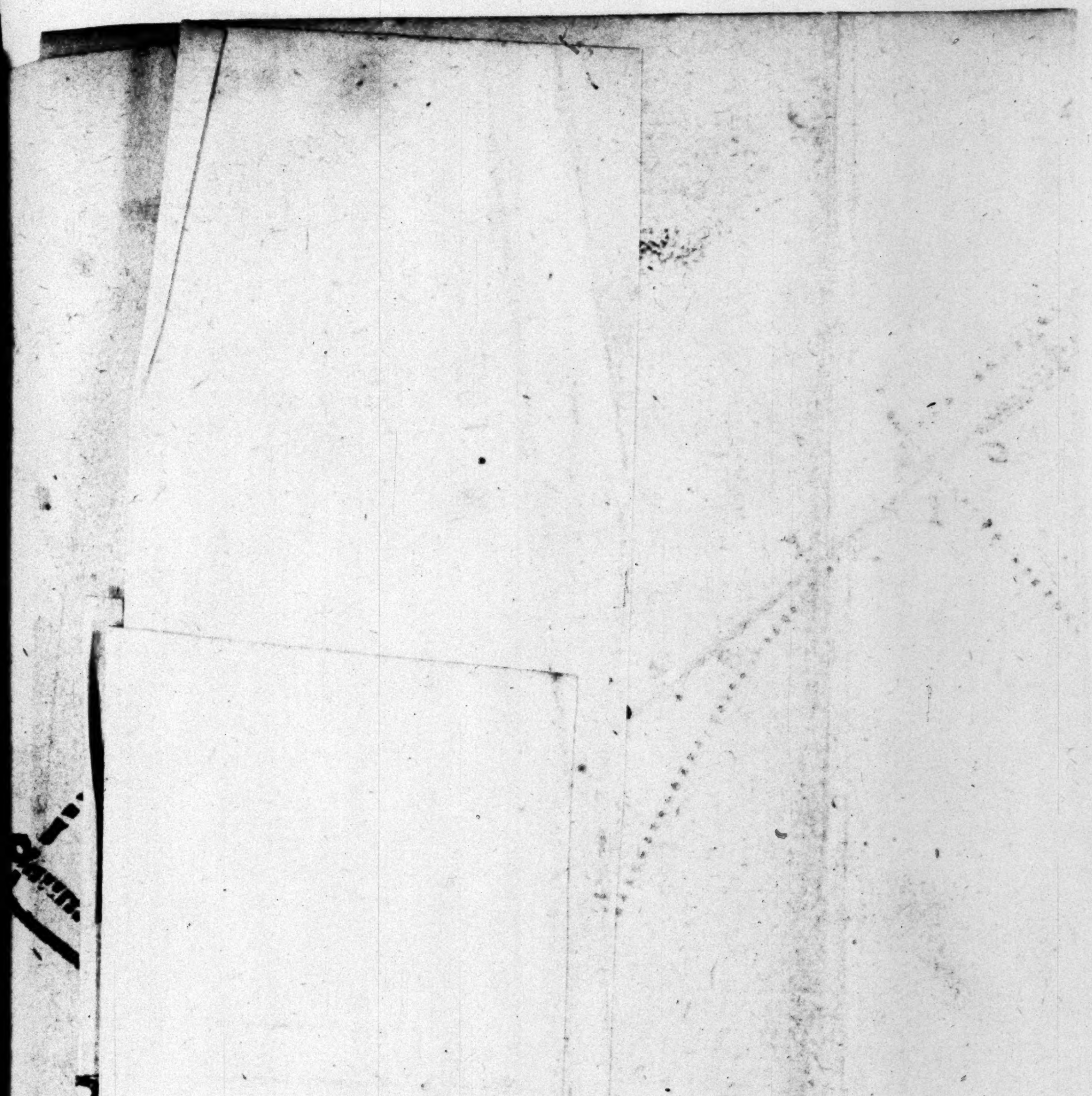
Houres and parts.		*Equinoctiall distances.*		*Naturall tangents.*
4	8	35	0	700
	½	27	30	520
5	7	20	0	364
	½	12	30	221
6	6	5	0	087
	½	Substile		
		2	30	044
7	5	10	0	175
	½	17	30	315
8	4	25	0	466
	½	32	30	637
9	3	40	0	8 9
	½	47	30	1091
10	2	55	0	1428
	½	62	30	1921
11	1	70	0	2747
	½	77	30	4511
12	12	85.	0	11430

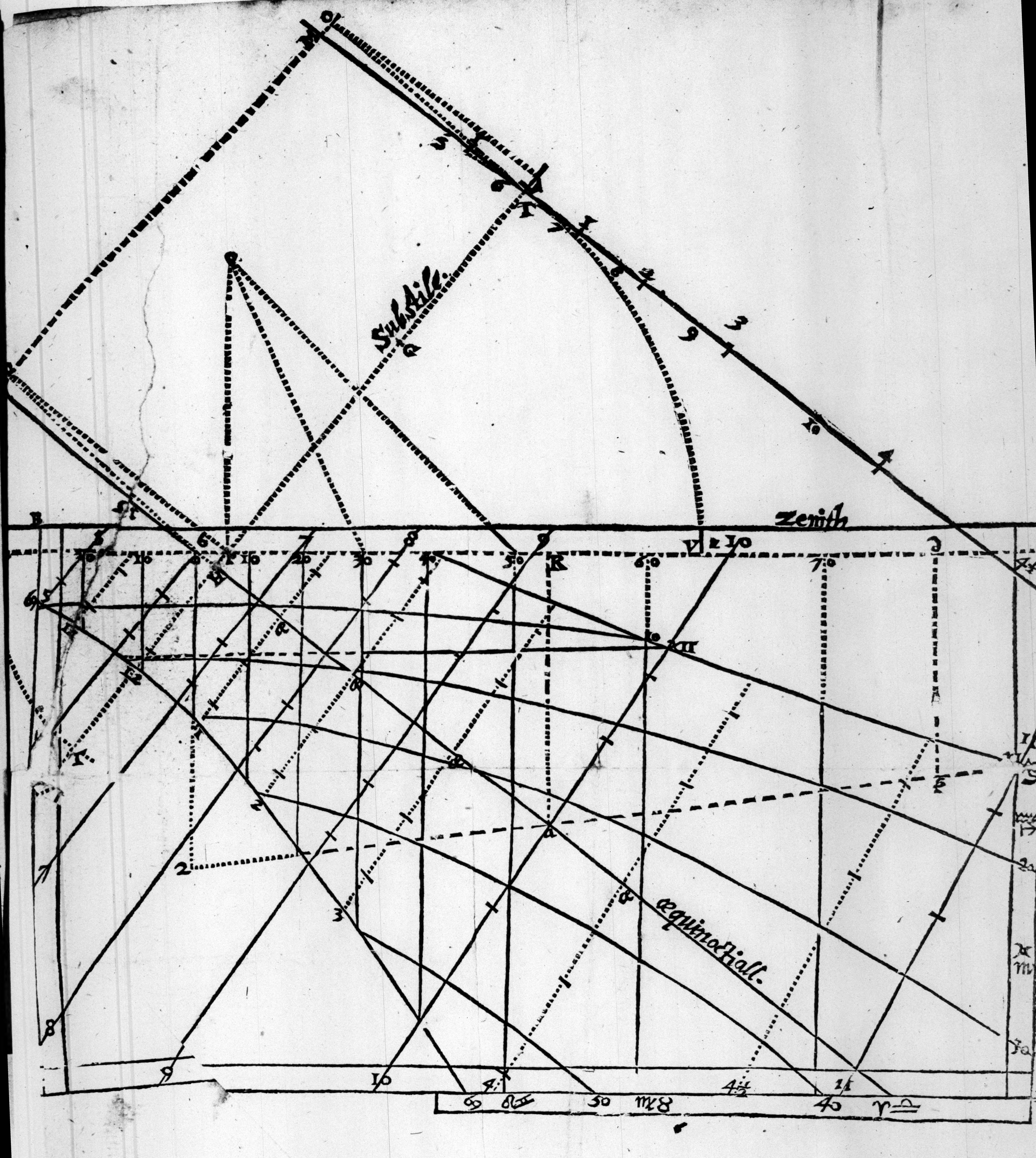
The Geometricall projection.

Proportion the plane B C D E, whereupon you will draw the Diall, to what ſcantling you think fit, as here it is to foure foot, and ſeven foot, allowing for the ſcale an inch to a foot: let V R d paralell to B E, be the horizontall line drawn where you will, upon any part thereof, as at P, make choice of a fit place for the perpendicular ſtile, (though afterwards you may uſe another form) neere about the upper part of the plane, becauſe the great angle between the two meridians maketh the ſubſtile which muſt paſſe thorow the point P, to fall ſo neere the 6 of clock houre, that you can put but one houre above it, if you will bring 11 of clock, more uſefull than 4, into the plane; let P be the center, and with any chord (the greater the better) make two obſcure arches, one above the horizontall line, the other under the ſame; off the ſame chord take 51 d. 42′, the angle between the ſubſtile and horizon (which is the complement of the angle between the ſubſtile and meridian) and ſet it from V to T both wayes, draw the ſtreight line T P T, which ſhall be the ſubſtile of this Diall. This done, ſuppoſe an equinoctiall line in your imagination, (or draw a deleble line if you will) cutting the ſubſtile at right angles, as neere the true place as you can gueſſe, upon which proportion the diſtance of either of the extreme houres of the Dyall, as great or as little as may juſtly fill the plane: for example, let 5 of clock be $\frac{75}{100}$ parts of an inch from the ſubſtile (which is 9 inches off, accounting an inch to a foot) & I would find out the length of the radius agreeable thereto, by which to try if the other extream houre will alſo fall out conveniently upon the plane, wherefore *by the ſecond caſe of R. P. triangles*, I ſay,

		Logar.
As r H the tangent of 20 d. the equinoctiall diſtance of 5 of clock from the ſubſtile	+	9561.06
Is to the line r H 0 75 parts . . .	—	0124.94
So is the radius H G upon the ſubſtile . .	+	10000.00
To the line H G, or H O, 2 061 parts . .	+	0314.00

Or





Place this folio 126.

Or by the same case,

		Logar.
As the sine of r G H 20 d.	+	9534.0516
Is to the line r H 75 parts	—	0124.9387
So is the sine of G r H 70 d	+	9972.6858
To the line G H 2061 parts	+	0313.9955

Now making the line G H 206 the Radius, that is, 2 inches and $\frac{6}{100}$ parts, and opening the sector to the width, try whether 2747 the naturall tangent of 70 d. the equinoctiall distance of 11 of clock from the substile, set off from H upon the equinoctiall line, will fall within the plane; if not, make this Radius, and consequently the houres greater or lesser till they justly fill the plane, which will follow in due proportion, because the equinoctiall line K H ♈, is a tangent line to the circle, drawn upon the Radius, or semidiameter H G. From this ground you may also finde the length of the Radius by the greatnesse of the plane, (as in the ninth Chapter) adde 364 and 2747 the naturall tangents of 5 and 11, the two extream houres together, so have you 3111 that is three times the radius, and 11 hundred parts, for the distance of those two houres, by which divide the radius (encreased for more exactnesse with as many ciphers as you will) the quotient will bee 321, or seeke the arithmeticall complement of the logarithme of 3111 in the chiliads, *vizt.* 0507.1000, and that shall give you the length of the radius 321, as afore. Then open the sector to the width of 5 and 11, (which two points you may assigne where you please upon the equator) take thereof 32 parts, which shall bee the true length of the radius desired. When you have fitted the radius for the two extream houres, all the rest may be put on by the tangents proper to them, but it will be first necessary to finde the length of the perpendicular stile, by help whereof to draw the equinoctiall line in the true place, therefore in the triangle H O P, right angled at P, *by the first case of R. P. triangles.*

As the sine of H P O	$90^{d}\ 0'$	10000.00
Is to the line H O	2061	0314.00
So is the cosine of H O P	3 58	9998.96
To the line O P	2056	10312.96

 Now

Now making 2056 *vizt.* 2 inches, and $\frac{56}{1000}$ parts, the length of the perpendicular ſtile O P to be the radius, the ſubſtile T P I ſhall be a tangent line thereunto, and P H the diſtance of the equator from P, is 069 parts, the naturall tangent of 3 d. 58′, the heighth of the pole above this plane, by which point H draw the line before imagined, which, if you have not erred will cut the horizontall line at 6 of clock, and make an angle with the horizon of 38 d. 18′, equall to the diſtance of the ſubſtile from the meridian; upon this line (making H O, or H G to bee the radius) you may by the former rule with a ſcale of inches, or by the ſector, or by a line divided equall to H O (as in the firſt Chapter) by help of the naturall tangents aforeſaid ſet on all the reſt of the houre diſtances that you deſire; for example in 11 of clock, *by the ſecond caſe of R. P. triangles.*

		Logar.
As the radius H G or H O		10000.00
Is to the line H O	2061	0314.00
So is H 11 the tang. of H G 11	$70^d\ 0'$	10438.93
To the line H 11	5662	10752.93

Which is 5 inches and 66 hundred parts for the diſtance of 11 of clock from the point H, and ſo of the reſt; or for brevity's ſake, take the logarithm of H O 0314.00 into a peece of paper, & ad it to each Log. tangent of 5 d. 10 d. 25 d. 40 d. &c. ſo ſhall you beget new logarithmes, which being found in the chiliads, ſhall yeeld abſolute numbers, that taken off the ſcale of inches, and ſet from the ſubſtile both wayes, will give the true diſtance of each houre and part upon this equinoctiall line, agreeable with the naturall tangents aforeſaid taken off the ſector. Having done with this equinoctiall, you muſt do the like with another, which may bee drawn above or beneath this without reſpect; to finde the place whereof, it will bee neceſſary firſt to know the length of the whole line from H the equinoctiall to the center of the Diall in parts of the perpendicular ſtile P O, if you will work by the ſcale of inches, or in naturall tangents, if by the ſector; wherefore *by the ſecond caſe of R. P. triangles.*

As

		Logar.
As the radius P O		10000.00
Is to the line P O	206	0314.07
So is the tangent of P O H	$3^{d}\,58'$	8840.99
To the line P H	014 —	9155.06
	Compl. char. 0.	
And so is the tang. of P O M	$86^{d}\,2'$	11159.00
To the line P center	2972	~~1~~1473.07

Adde the two lines of 014 and 2972 together, so have you the whole line 2986 from the equinoctiall to the center, in parts of the radius P O, *vizt.* 29 inches, and $\frac{68}{100}$ parts, out of this line abate what parts you please, (if you will draw the second equinoctiall line above the first, or adde them if you will draw it under) suppose 343 that is 3 inches and $\frac{43}{100}$ parts, which set from H to L upon the substile, draw another equinoctiall by L, parallell to the former ; then will L O be a new radius for this equinoctiall line, as H O was for the former, and is thus easily found *by the fourth of the sixt book of Euclide.*

		Logar. Ar. Compl.
As the whole line H center	2986	8524.90
Is to the Radius H O in parts	206	0314.00
So is L cent. (343 In. being abated)	2643	1422.10 *Ar. compl.*
To the radius L O in parts	182	~~1~~0261.00

Having the length of L O one inch and $\frac{82}{100}$ parts, make that the radius, then shall M L 4 be a tangent line thereunto ; open the sector to the width of L O, (or divide a line, as in the first Chapter) and take off from either of them the same houre distances, which set upon this equinoctiall line, as you did upon the former, you have two pricks for every houre (upon each equinoctiall line one) by which to draw the true houre lines, without regard to the center at all. Now may you draw a line from O to O, at the length of each radius H O, and L O, which shall be the true heighth of a triangular stile representing the axis, to be continued as farre as you will ; which you may also finde upon each equinoctiall line for more certainty sake, in this manner ; *by the first case of R. P. triangles.*

As

		Logar.
As the sine of H K O	86 d 2′	9998.95
or L M O		
Is to the line H O	206	0314.00
or		
L O	182	0261.00
So is the sine of H O K	90 d 0′	10000.00
or L O M		
To the line H K	2066	0315.05
or		
L M	1829	0262.05

Set of 2066 inches from H to K, and 1829 inches from L to M (by help of a scale of inches) so have you fower pricks to draw the axis by.

The operation by naturall Tangents.

But if you will work by naturall Tangents only, you may with some lesse labour attaine your desire in this manner : Having drawn the horizontall line and substile as afore, proportion the length of P O the perpendicular stile, to what scantling you will: let that be the radius, then is P H the naturall tangent of 3 d. 58′, 069 parts of a radius, which take off the sector opened to the width of P O, and set it from P to H ; next let H O be the radius, and set off the naturall tangent of 20 d. 364 from H upwards for 5 of clock, and the naturall tangent of 70 d. 274 from H downwards for 11 of clock ; if these two houre distances fit the plane to your liking, proceed, if not, make P O greater or lesser as you see cause, according to which the distance of H from P, by which the equinoctiall line must bee drawn, and the length of H O, and the width of all the houre lines do proportionally vary. Or if you like it better, you may at first (by the former rule) finde the length of P O proportionable to the width of the two extream houres 5 and 11, which you may prescribe at your pleasure. Having fitted the houres upon this line, draw another ; to performe which, let P O bee the radius againe, then is P H the naturall tangent of 3 d. 58′, 069 parts,

and

and P center, the naturall tangent of 86 d. 2', $14\underline{421}$, adde them together, you have the whole line H center, $14\underline{490}$ that is 14 times the radius, and $\frac{49}{100}$ parts, out of which subtract what number of parts you will, the rest is the distance from the second equinoctiall to the center, suppose $1\underline{58}$ that is 1 radius and $\frac{58}{100}$ parts, which set from H to L, by the point L draw the line M L 4 paralell to the former equinoctiall, and there will remain from L to the center $12\underline{91}$. Now seek the length of L O which is the radius for this line, as H O was for the former, let H O therfore be given in some known parts $3\underline{21}$ that is $\frac{32}{100}$ parts next hand of the width of the two extream houres 5 and 11, *by the former fourth of the sixt booke of Euclid.*

			Logar.
As the whole line H center	$14\underline{49}$	+	1161.08
Is to the radius H O in parts	$3\underline{21}$	—	0493.50
So is the line L center	$12\underline{91}$	+	1110.92
To the radius L O in parts	$2\underline{86}$	—	9456.34

Compl. char. 0.

Now making L O the radius, open the sector to that width, and set on the naturall tangents of every houres distance upon this equinoctiall line, as you did upon the former, so have you two pricks to draw each houre line by, as you had before; the axis or stile line K O M O is found as in the former work, which must crosse H O and L O at right angles, and being drawn, you have done. All this by help of a line of 12 inches divided into 10 parts, and $\frac{1}{10}$ part subdivided into 100 (as hath been formerly shewed) may be easily transferred from the paper into the plane. Thus may you take your choyce, whether you will give the width of either extream houre, and from thence argue the length of the radius, and other things unknown; or else give the length of the perpendicular stile, and by that proportion the rest; or thirdly give the capacity of the plane, and thereby collect the length of the radius, &c. for all three wayes you may easily obtain your desire.

And note, that if you will content your selfe with fewer houres, you may put the substile into the middle of the plane, and taking in but the houres of 4 and 9, you may make every houres

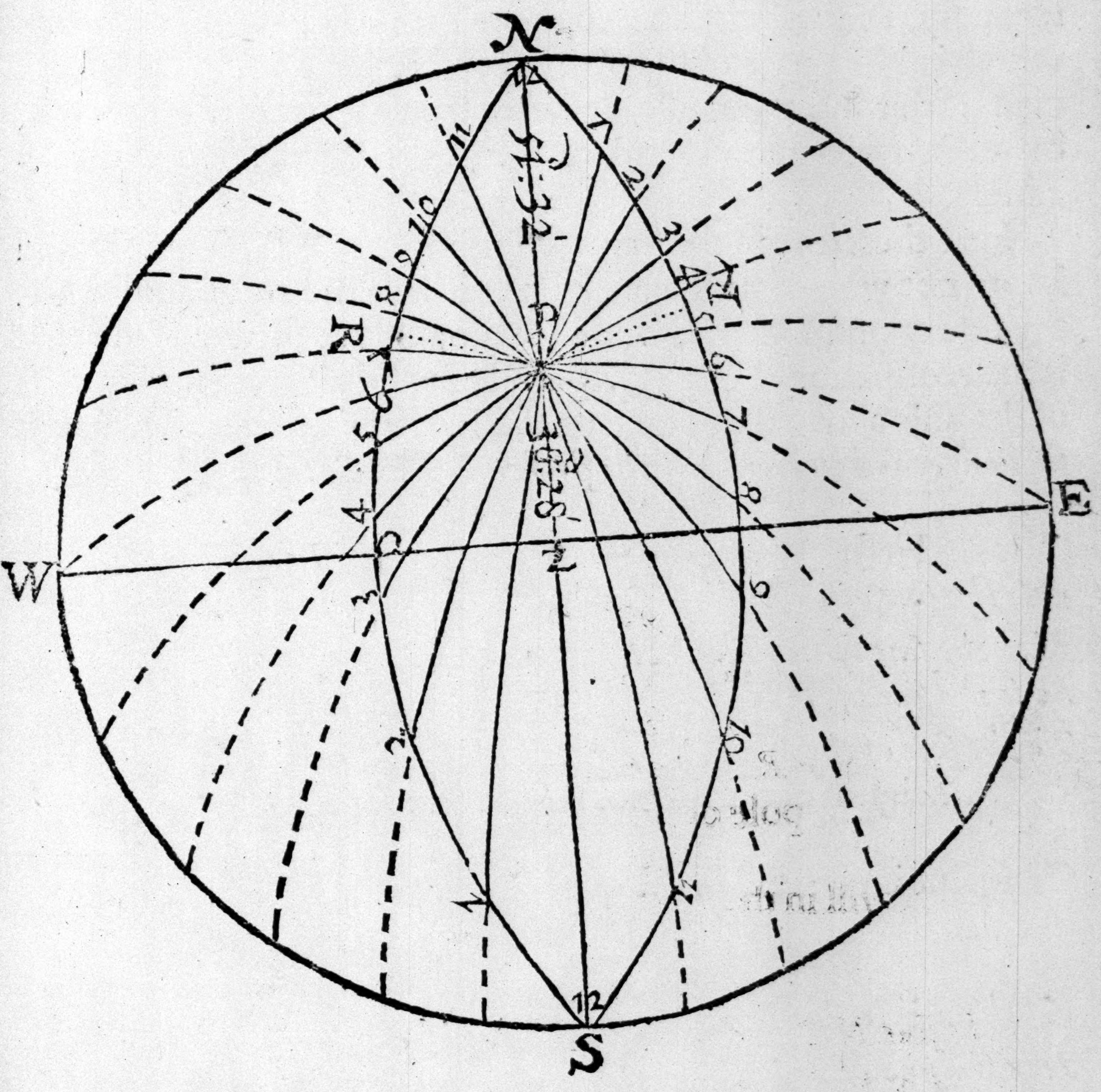
houres distance twice as great as it was; but if you be not confined by the plane, neither are you limited in the width of the houre lines.

CHAP. XII.

To draw the houre lines upon any direct plane, reclining or inclining East or West.

HItherto I have only spoken of such planes as are either paralell or perpendicular to the horizon, all which, excepting the horizontall, lie in the plane of some azimuth or other: The rest that follow are reclining from the zenith, or inclining to the horizon, according to the respect of the upper or nether faces of the planes. In these the base is a line in the plane, paralell to the horizon, and alwayes situat in some azimuth or other. So doth the base of the East and West reclining plane lie in the meridian, or South and North azimuth, and the poles thereof in the prime verticall; but the plane it selfe in some circle of position, (as it is astrologically taken) which is a great circle of the Sphere, passing by the North and South intersections of the meridian and horizon, and falling East or West from the zenith upon the prime verticall, as much as the poles of the plane are elevated, and depressed above and under the horizon. And this kind of plane rightly conceived, and represented in the schem by N O S or N 9 S, is no other but an erect declining plane in any Country where the pole is elevated the complement of ours: for if you consider the Sphere, it is apparant that as all the azimuths representing the decliners, do crosse the prime verticall in the zenith, and fall at right angles upon the horizon, so do all the circles of position representing the reclining and inclining East or West planes, crosse the horizon in the North and South points of the meridian, and fall at right angles upon the prime verticall. From which analogy it commeth to passe, that making a Diall declining

ning 30 d. from the meridian, it ſhall bee the ſame that a reclining 30 d. from the zenith, and contrary, only changing the elevation of the pole into the complement thereof, becauſe the prime verticall in this caſe is ſuppoſed to be the horizon, above which the pole is alwayes elevated the complement of the heighth thereof above the horizon.



Data	Elevation of the pole	$51^{d}\ 32'$	N P
	Reclination E or W	35 o	Z 9, or Z 9

Quæſita	1 The heighth of the ſtile P R	26^{d}	$41'$
	2 The diſtance of ſubſt. & merid. R N	45	52
	3 The angle between the meridians R P N	66	27

The

The Demonstration.

Before the making of the Diall, draw the schem by the rules of the fourth Chap. then find (as in all decliners) first the elevation of the pole above the plane, which is P R, part of the meridian of the plane, beeween the pole of the world and the plane: secondly, the distance thereof from the meridian of the place, which is N R, part of the plane betwixt the substile and meridian: thirdly, the angle betwixt these two meridians N P R, by which you may calculate the houre distances as in the decliners.

First therefore in the supposed triangle N P R (because you know not yet where R shall fall) you have the right angle at R, the side opposite P N 51 d. 32′, & the angle at N, whose measure is the reclination Z O 35 d. to finde the side P R, the elevation of the pole above the plane, or the heighth of the stile, *by the first or second varieties of the first case of R. S. triangles.*

First,			*Logar.*
As the sine of P R N	90^d	0′	10000.00
Is to the sine of the side P N	51	32	9893.74
So is the sine of P N R	35	0	9758.59
To the sine of the side P R	26	41	19652.33

The heighth of the pole or stile above the plane.

Or againe if you will in the quadrantall N Z O, by the same case.

			Logar.
As the whole sine N Z	90^d	0′	10000.00
Is to the sine of N P	51	32	9893.74
So is the sine of Z O	35	0	9758.59
To the sine of P R	26	41	19652.33

Secondly, you may finde the side N R, which is the distance of the substile and meridian, *by the two varieties of the second, third, and fourth cases of R. S. triangles.*

As

As the sine of P R N	90d 0'	10000.00
Is to the tangent of the base P N	51 32	10099.91
So is the cosine of the angle P N R	35 0	9913.36
To the tangent of the side N R	45 52	10013.37

The distance of the substile from the meridian.

Thirdly, the angle at P between the two meridians may bee found *by the two varieties of the* 11, 12, 13, 14, 15, *and* 16 *cases of R. S. triangles.*

		Logar.
As the sine of the side P N	51d 32'	9893.74
Is to the sine of the angle P R N	90 0	10000.00
So is the sine of the side N R	45 52	9855.95
To the sine of the angle R P N	66 27	9962.21

The angle at P being 66 d. 27', must needs fall between 7 and 8 of clock, because 8 is 60 d. distant from the meridian, and 7 is 75 d. distant, therefore now let fall a perpendicular from P to R, somewhat neere the middle, between 7 and 8 of clock, which will help to direct the fancy in calculating the houres.

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane	Differ.
8	4	6d.27'	8056.81	2d.54'	
	½	13.27	9047.49	6.22	3d.28'
9	3	21.27	9246.62	10. 0	3. 38
	½	28.57	9395.19	13.57	3. 57
10	2	36.27	9520.95	18.21	4. 24
	½	43.57	9636.41	23.25	5. 4
11	1	51.27	9750.95	29.24	5. 59
	½	58.57	9872.70	36.43	7. 19
12	12	66.27	10013.00	45.51	9. 8
	½	73.57	10193.41	57.21	11.30
1	11	81.27	10475.25	71.29	14. 8
	½	88.57	11399.22	87.40	16.11

Houres

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
	$\frac{1}{2}$	1^{d}. 3′	7905.45	0^{d}. 28′	3^{d}.24′
7	5	8. 33	8829.42	3. 52	3. 30
	$\frac{1}{2}$	16. 3	9110.28	7. 22	3. 42
6	6	23.33	9291.62	11. 4	4. 4
	$\frac{1}{2}$	31. 3	9481.94	15. 8	4. 33
5	7	38.33	9553.42	19.41	5. 18
	$\frac{1}{2}$	46. 3	9668.26	24.59	6. 19
4	8	58.33	9783.92	31.18	7. 46
	$\frac{1}{2}$	61. 3	9009.47	39. 4	9. 45
3	9	68.33	10058.05	48.49	12.24
	$\frac{1}{2}$	76. 3	10257.68	61. 3	14.49
2	10	83.33	10599.05	75.50	

The Arithmeticall calculation.

Now make the table, (as heretofore directed) beginning wi 8 of clock, and ending with 7 $\frac{1}{2}$, as you see in the example ; down by those houres all the equinoctiall distances from t substile, *viz.* for 8 of clock 6 d. 27′, for 9 of clock 21 d. 27′, a so of the rest ; then seek the true houre distances upon the pla *by the first variety of the fift case of R. S. triangles* ; for in the t angle R P 8,

		Logar.
As the sine of P R 8	90^{d} 0′	10000.00
Is to the tangent of RP 8	6 27	9053.28
So is the sine of the side P R	26 41	9652.33
To the tangent of the side R 8	2 54	18705.61

This 2 d. 54′ is the true distance of 8 of clock from the su stile. And there is no other difference at all in calculating t rest of the houres, but encreasing the angle at P according each houres equinoctiall distance from the substile.

Therefore now take into a Paper the Logar. sine of P R, t elevation of the stile, which is 9652.33, and adde it continuall

The Demonstration.

Before the making of the Diall, draw the ſchem by the rules of the fourth Chap. then find (as in all decliners) firſt the elevation of the pole above the plane, which is P R, part of the meridian of the plane, beeween the pole of the world and the plane: ſecondly, the diſtance thereof from the meridian of the place, which is N R, part of the plane betwixt the ſubſtile and meridian: thirdly, the angle betwixt theſe two meridians N P R, by which you may calculate the houre diſtances as in the decliners.

Firſt therefore in the ſuppoſed triangle N P R (becauſe you know not yet where R ſhall fall) you have the right angle at R, the ſide oppoſite P N 51 d. 32′, & the angle at N, whoſe meaſure is the reclination Z O 35 d. to finde the ſide P R, the elevation of the pole above the plane, or the heighth of the ſtile, *by the firſt or ſecond varieties of the firſt caſe of R. S. triangles.*

First,			Logar.
As the ſine of P R N	90^{d}	0′	10000.00
Is to the ſine of the ſide P N	51	32	9893.74
So is the ſine of P N R	35	0	9758.59
To the ſine of the ſide P R	26	41	X9652.33

The heighth of the pole or ſtile above the plane.

Or againe if you will in the quadrantall N Z O, by the ſame caſe.

			Logar.
As the whole ſine N Z	90^{d}	0′	10000.00
Is to the ſine of N P	51	32	9893.74
So is the ſine of Z O	35	0	9758.59
To the ſine of P R	26	41	X9652.33

Secondly, you may finde the ſide N R, which is the diſtance of the ſubſtile and meridian, *by the two varieties of the ſecond, third, and fourth caſes of R. S. triangles.*

As

As the sine of P R N	90^{d} 0'	10000.00
Is to the tangent of the base P N	51 32	10099.91
So is the cosine of the angle P N R	35 0	9913.36
To the tangent of the side N R	45 52	10013.37

The distance of the substile from the meridian.

Thirdly, the angle at P between the two meridians may bee found *by the two varieties of the* 11, 12, 13, 14, 15, *and* 16 *cases of R. S. triangles.*

		Logar.
As the sine of the side P N	51^{d} 32'	9893.74
Is to the sine of the angle P R N	90 0	10000.00
So is the sine of the side N R	45 52	9855.95
To the sine of the angle R P N	66 27	9962.21

The angle at P being 66 d. 27', must needs fall between 7 and 8 of clock, because 8 is 60 d. distant from the meridian, and 7 is 75 d. distant, therefore now let fall a perpendicular from P to R, somewhat neere the middle, between 7 and 8 of clock, which will help to direct the fancy in calculating the houres.

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane	Differ.
8	4	$6^{d}.27'$	8056.81	$2^{d}.54'$	
	½	13.27	9047.49	6.22	$3^{d}.28'$
9	3	21.27	9246.62	10. 0	3. 38
	½	28.57	9395.19	13.57	3. 57
10	2	36.27	9520.95	18.21	4. 24
	½	43.57	9636.41	23.25	5. 4
11	1	51.27	9750.95	29.24	5. 59
	½	58.57	9872.70	36.43	7. 19
12	12	66.27	10013.00	45.51	9. 8
	½	73.57	10193.41	57.21	11.30
1	11	81.27	10475.25	71.29	14. 8
	½	88.57	11399.22	87.40	16.11

Houres

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
	½	1d. 3′	7905.45	0d. 28′	3d.24′
7	5	8. 33	8829.42	3. 52	3. 30
	½	16. 3	9110.28	7. 22	3. 42
6	6	23.33	9291.62	11. 4	4. 4
	½	31. 3	9481.94	15. 8	4. 33
5	7	38.33	9553.42	19.41	5. 18
	½	46. 3	9668.26	24.59	6. 19
4	8	58.33	9783.92	31.18	7. 46
	½	61. 3	9009.47	39. 4	9. 45
3	9	68.33	10058.05	48.49	12.24
	½	76. 3	10257.68	61. 3	14.49
2	10	83.33	10599.05	75.50	

The Arithmeticall calculation.

Now make the table, (as heretofore directed) beginning with 8 of clock, and ending with 7 ½, as you see in the example; set down by those houres all the equinoctiall distances from the substile, *viz.* for 8 of clock 6 d. 27′, for 9 of clock 21 d. 27′, and so of the rest; then seek the true houre distances upon the plane, *by the first variety of the fift case of R. S. triangles*; for in the triangle R P 8,

		Logar.
As the sine of P R 8	90d 0′	10000.00
Js to the tangent of RP8	6 27	9053.28
So is the sine of the side P R	26 41	9652.33
To the tangent of the side R 8	2 54	18705.61

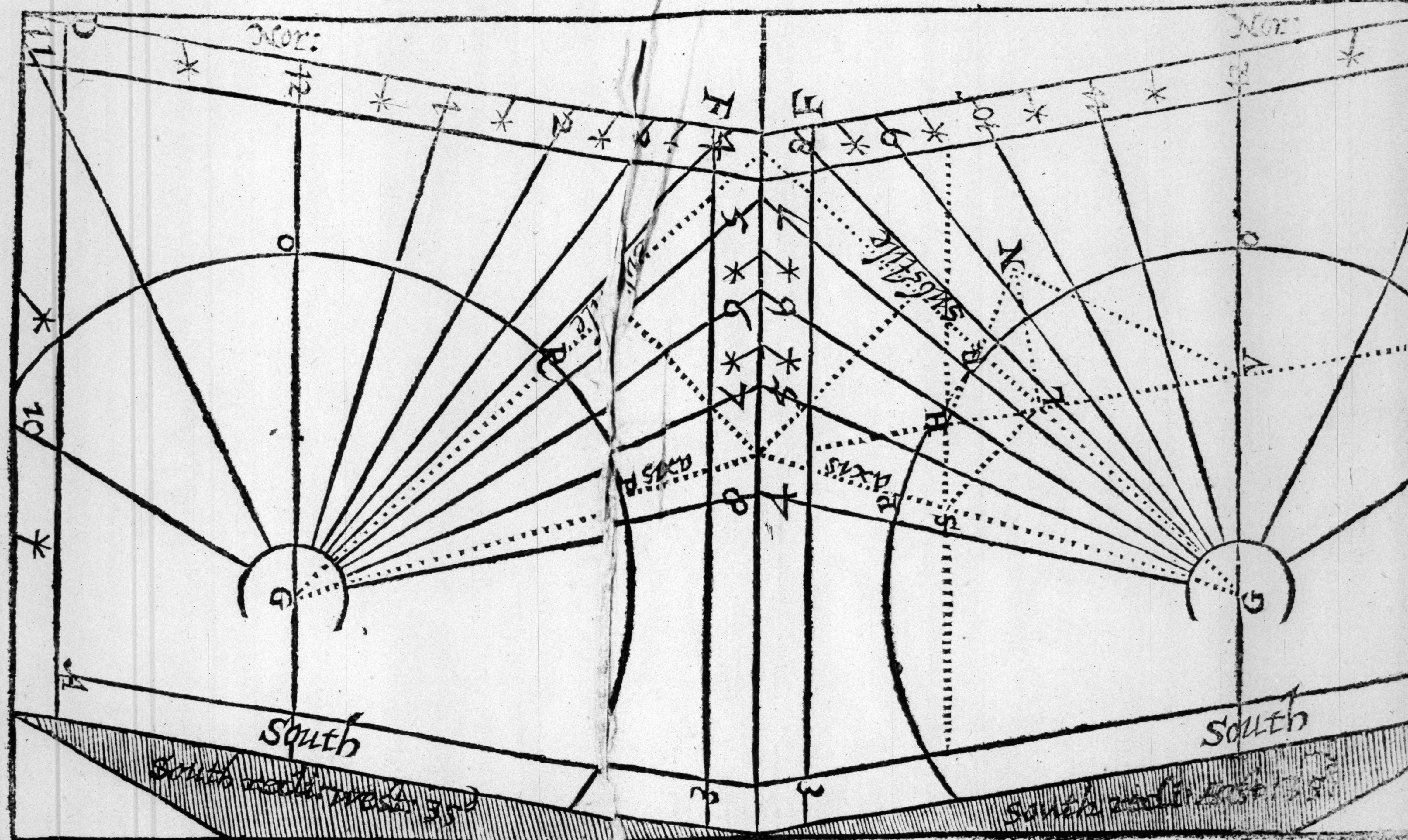
This 2 d. 54′ is the true distance of 8 of clock from the substile. And there is no other difference at all in calculating the rest of the houres, but encreasing the angle at P according to each houres equinoctiall distance from the substile.

Therefore now take into a Paper the Logar. sine of P R, the elevation of the stile, which is 9652.33, and adde it continually

to

to the Logar. tangents of every houres equinoctiall distance and complemen ... in the Table, so shall you produce new Log.

so haue you finished this Diall for use, only remember, because the Sunne riseth but a little before 4, and setteth a little after 8,



Place this folio 137.

to the Logar. tangents of every houres equinoctiall distance and complement, as they stand in the Table, so shall you produce new Log. tangents, the arches whereof are the true houre distances to be set from the substile both wayes upon the plane, as in the example you see done.

The Geometricall projection.

Having calculated the houre distances, you shall thus make the Diall; Let A D be the base, or horizontall line of the plane, paralell to N Z S the meridian line of the schem; and A D E F the plane reclining 35 d. from the zenith, as doth S O N of the schem, thorow any part of the plane (but most convenient for the houres) draw a line paralell to the base A D, which shall be G o 12, the 12 of clock houre, representing N Z S of the schem, because the base A D is paralell to the meridian: Take 60 d. of the chord, and making G the center, draw the circle P R O, representing the circle of position N 3 S of the schem, in which this plane lieth: From the point O to R westerly in the east reclining, and easterly in the west reclining, set off the distance of the substile and meridian, formerly found to be 45 d. 53', and draw the prickt line G R, for the substile agreeable to the site of P R in the schem; G O of the Diall, representing the arch P N of the meridian in the schem; and O R the arch N R of the plane. From the point R of the substile both wayes (as the table doth direct you) set off the houre distances by help of the chord; *vizt.* for 8 of clock 2 d. 55', for 7 of clock 3 d. 51', for 9 of clock 10 d. 1', and so of the rest, and draw streight lines from the center G thorow those points, which shall be the true houre lines desired. Last of all, the heighth of the stile P R 26 d. 41' being set from R to P, draw the streight line G P for the axis of the stile, which must give the shadow to the Diall: Erect G P at the angle R G P perpendicularly over the substile line G R, and let the point P bee directed to the north pole, G o 12 placed in the meridian, the center G respecting the south, and the plane at E F elevated above the horizon 55 d. so have you finished this Diall for use, only remember, because the Sunne riseth but a little before 4, and setteth a little after 8,

to leave out the houres of 3 and 9, and put on all the rest.

And thus have you (as before) at one work made foure Dials, *vizt.* the east reclining, and west inclining as much, both of them represented by the circle N 3 S, wherein there is no difference but the stile representing the north, and the plane the zenith in the recliner, but the south pole and nadir in the incliner, and the number of the houres altered, as the turning of the Dials will require. In like manner, these Dials do directly agree with the other two, *vizt.* the west reclining 35 d. and the east inclining as much, as by plaine ocular inspection appeareth in the schem, where all the houre circles comming from the pole do cut the planes of the two last sort of Dials represented by the circle of position N 9 S, with the very same angles that they did the other two represented by the circle of position N 3 S; only the former cautions observed, of directing the stile, and writing the houres; which being placed on each side the meridian, as the schem it selfe directeth, you cannot erre. These things considered, that there is no essentiall difference between these Dials, I make all foure to be but one, as is aforesayd.

CHAP. XIII.

To draw the houre lines upon any direct south reclining or inclining plane.

AS the base of east and west reclining or inclining planes doth alwayes lie in the meridian of the place, or paralell thereto, and the poles in the prime verticall; so doth the base of south and north reclining, or inclining planes, lie in the prime verticall, or azimuth of east and west: and their poles consequently in the meridian, from whence (as all other planes do) they receive their denomination. And now if you suppose the circle of position (which, Astrologically taken, is fixed in the intersection of the

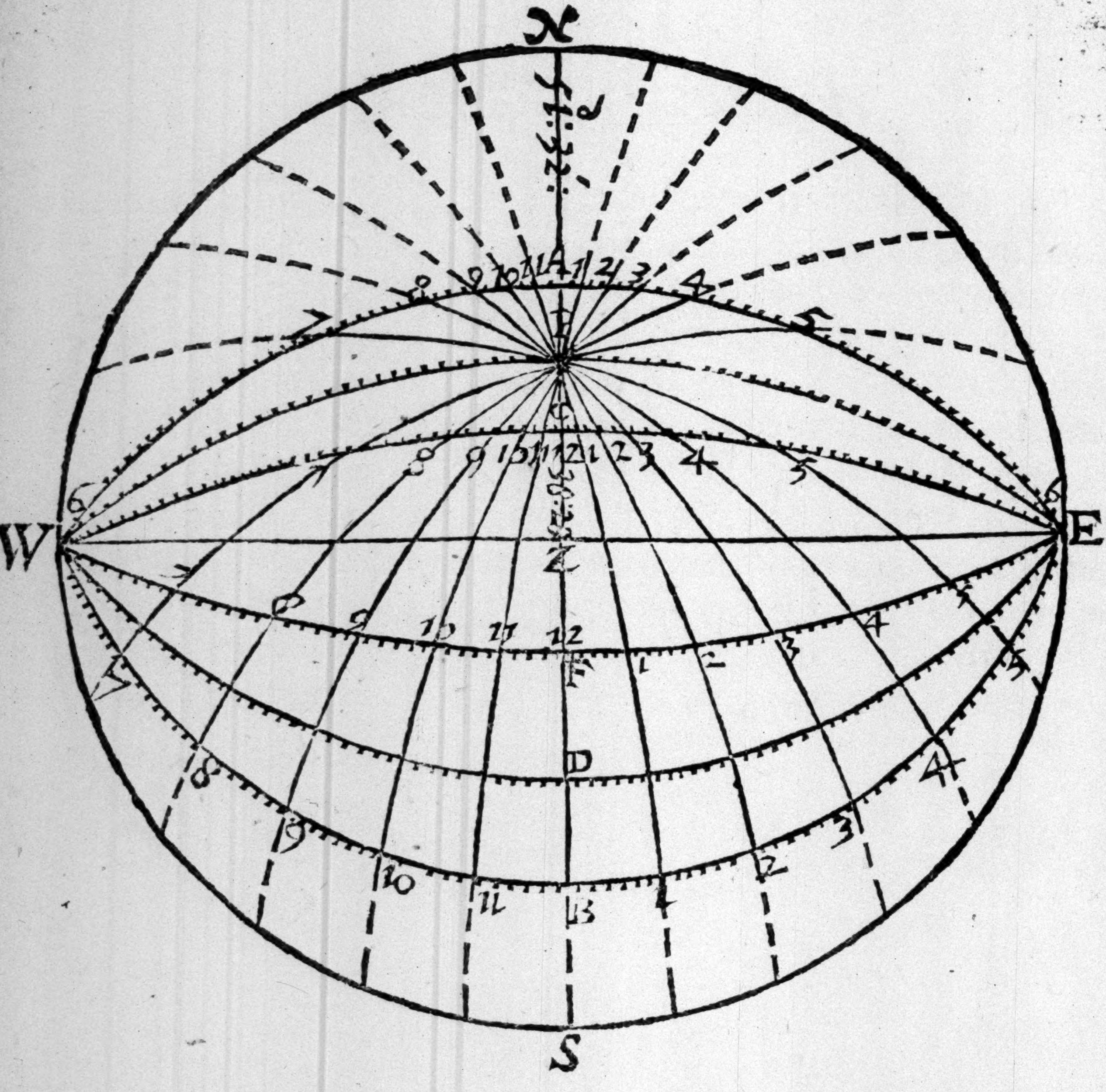
meridian

meridian and horizon to move about upon the horizon, till it comes into the plane of the prime verticall, and being fixed in the intersection thereof with the horizon, to bee let fall either way from the zenith upon the meridian, it shall truly represent all the south and north reclining, and inclining planes also. Of which there are six varieties, three of south, and three of north reclining. For either the south plane doth recline just to the pole, and then it becommeth an equinoctiall plane, as I call it, (or polar as some term it) because the poles of this plane do then lie in the equinoctiall: Or else it reclineth more and lesse than the pole, and consequently the poles of the plane above and under the equinoctiall, somewhat differing from the former: In like manner, the north plane reclineth just to the equinoctiall, and then becommeth a polar plane, as I call it, (or equinoctiall as some term it) because the poles of that plane lie in the poles of the world: or else it reclineth more, and lesse than the equinoctiall, and consequently the poles of the plane above and under the poles of the world, somewhat differing from the former.

The Demonstration.

These severall sorts of planes are all plainly represented to the eye, (in the schem adjoyning, drawn by the rules of the fourth Chapter:) by the six prickt circles, whereof the three to the northward of E Z W, are the three south recliners, and the three to the southward of E Z W, are the three north recliners; so called, because the poles of those planes have such respect to the north and south parts of heaven; and are elevated above the north and south points of the horizon N and S.

First therefore of the equinoctiall plane, and Diall to bee drawn thereon, represented by the circle E P W: wherein you may observe out of the schem it selfe, that this plane (lying in the 6 of clock houre circle, as the east and west do in the meridian) none of the other houre circles do cut the same; and therefore (as in the ninth Chapter) you may conclude, that the houre lines thereof have no center to meet in, but must bee paralell one to another, as in the east and west Dials they were.



And because this Diall is no other but the very horizontall of a right sphere, where the equinoctiall is zenith, and the poles of the world in the horizon, therefore it is not capable of the 6 of clock houre (no more than the east and west are of the 12 of clock houre) which vanish upon the planes, unto which they are paralell: and the 12 of clock houre is the middle line of this Diall, (because the meridian cutteth the plane of 6 of clock at right angles) which the Sunne attaineth not, till he be perpendicular to the plane. And this in my opinion, besides the respect of the poles, is reason enough to call it an equinoctiall Diall, seeing it is the Diall proper to them that live under the equinoctiall, as the circle divided into 24 equall parts may therefore

therefore be called polar, becauſe it is the Diall proper to them that are ſeated under the pole.

The Arithmeticall operation.

This Diall is to bee made in all reſpects as the eaſt and weſt were, being indeed the very ſame with them, only changing the numbers of the houres. For ſeeing the 6 of clock houre in which this plane lieth, croſſeth the 12 of clock houre at right angles: in which the eaſt and weſt plane lieth, the reſt of the houre lines will have equall reſpect to them both: ſo that the fift houre from 6 of clock is equall to the fift houre from 12 of clock, the fourth to the fourth, and ſo of the reſt. Theſe analogies holding, you may reſume the table of the ninth Chapter for your uſe here; only tranſpoſing the houres of 6 and 12. The equinoctiall diſtances and naturall tangents (which are the true houre diſtances upon the plane) not varying at all.

Houres and parts.		*Equinoctiall diſtances.*		*The houre diſtances upon the plane.*
		d	'	*tangent.*
12	0			
	$\frac{1}{2}$	7	30	132
11	1	15	0	268
	$\frac{1}{2}$	22	30	414
10	2	30	0	577
	$\frac{1}{2}$	37	30	767
9	3	45	0	1000
	$\frac{1}{2}$	52	30	1303
8	4	60	0	1732
	$\frac{1}{2}$	67	30	2414
7	5	75	0	3732
	$\frac{1}{2}$	82	30	7595
6	6	90	0	10000

The Geometricall projection.

Now then draw the tangent line H S K, paralell to the line E Z W; crosse it at right angles with N S A, the meridian line, which so intersecteth the plane in the schem. Make Z S or S A the radius to that tangent line, then is S α or S θ the naturall tangent of 30 d. S ϐ or S λ the naturall tangent of 45 d. S δ or S σ the naturall tangent of 60 d. &c. as in the table appeares: wherefore open the sector to the length of S A, (or divide a line equall thereto into 10 or 100 parts) and prick down the severall tangents as they stand in the table, from S both wayes (for α ϐ θ λ &c.) towards H and K, streight lines being drawn thorow those pricks, paralell to the meridian line N Z S A be the houre lines desired. Now suppose this paper were the plane on which you should draw the Diall; it is manifest, that making Z S of the schem or S A the radius, the plane is not capable of the 7 or 5 of clock houres, the whole plane H K being but foure times the radius: and these two houres distant seven times the radius and a halfe, as by the naturall tangents of each houre from 12 doth appeare. Wherefore if you will put all the houres upon the plane that it is capable of, you must reduce the radius (which is the length of the stile) by the rules of the ninth Chapter, to the greatnesse of the plane, and then proceed as aforesayd: let that radius be A B, then shall ♈ A ♎ be a tangent line to it; wherefore *by the second case of R. P. triangles.*

		Logar.	
As A ♎ the naturall tangent of 75 d.	3732 +	0571.94	*by the Chiliads alone.*
Is to A ♎ (in known parts of an inch) the semidiameter of the plane	350 +	0544.07	
So is A B the radius	1000 +	0000.00	
To A B the length of the stile in the same parts	94 —	9972.13	
		Comp: char. 0.	

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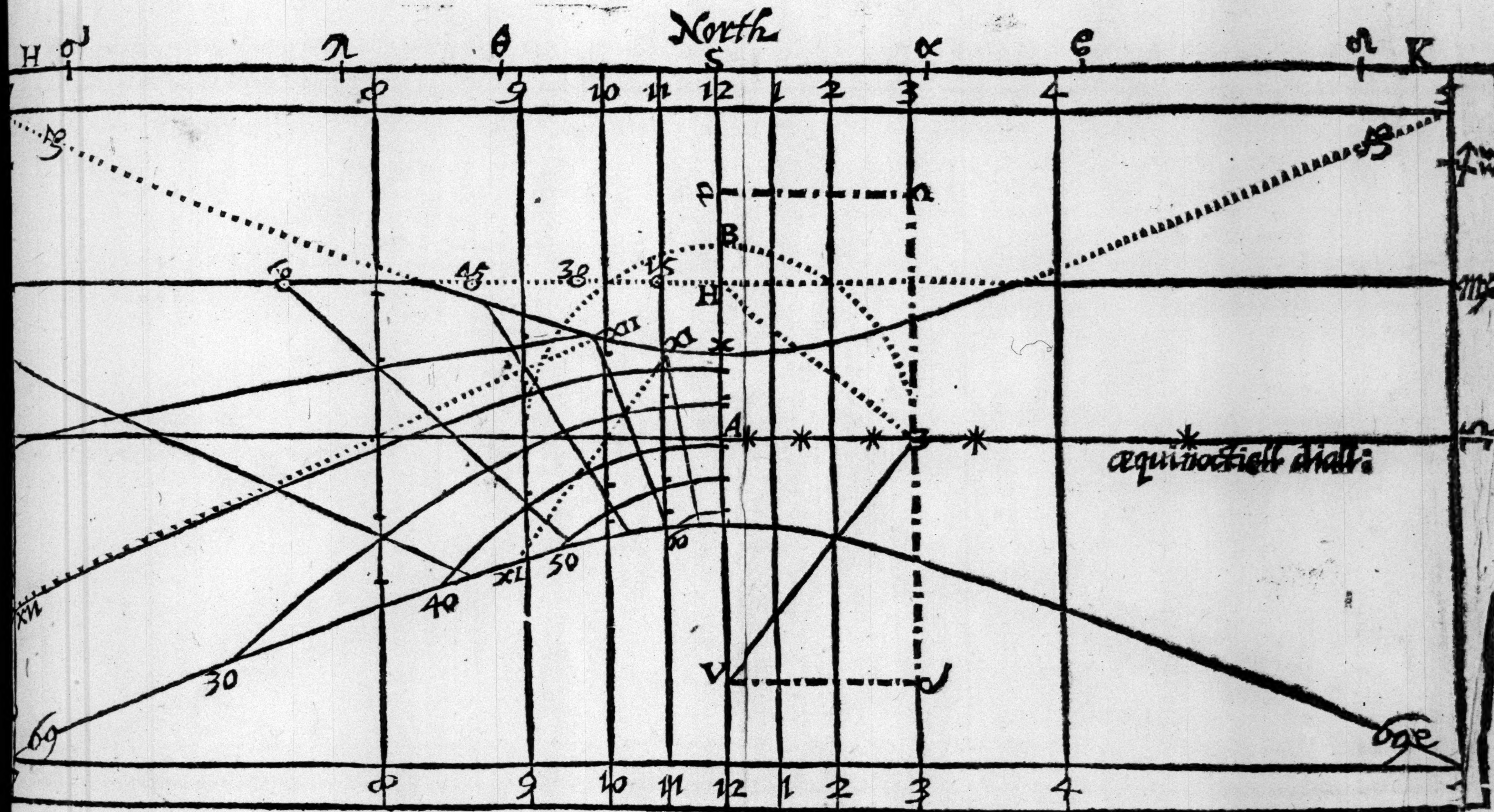


The line H S K *should be joyned to the former Scheme, as a Tangent line at* S.

Place this folio 142.

Or againe by the same case making ♎ A the radius, B A is a tangent line to it ; and contrary, if the length of the stile bee first given.

		Logar.
As ♎ A the radius	+	10000.00
Is to A B the tangent of 15 d.	+	9428.05
So is ♎ A in inches and parts 350	+	0544.07
To A B in the same parts 94		9972.12 *as afore.*

Comp. char. 0.

Wherefore to fetch in the houres of 7 and 5 upon this plane, you must reduce the radius or stile from Z S or S A to the length of A B 94 hundred parts of an inch, and then proceed to set on the houres by naturall tangents as aforesayd. The stile may be either a streight pin the length of A 3 or A B, erected at right angles to the plane in the point A, or a long square of the heighth of A 3 or A B, like a v c d, perpendicularly raysed over the 12 of clock houre line, so have you done : Let S A 12 bee placed in the meridian, and the whole plane at S raysed to the heighth of the pole 51 d. 32′, then will the stile shew the houres truly, and the Diall stand in its due position.

The second kinde South reclining lesse than the Pole.

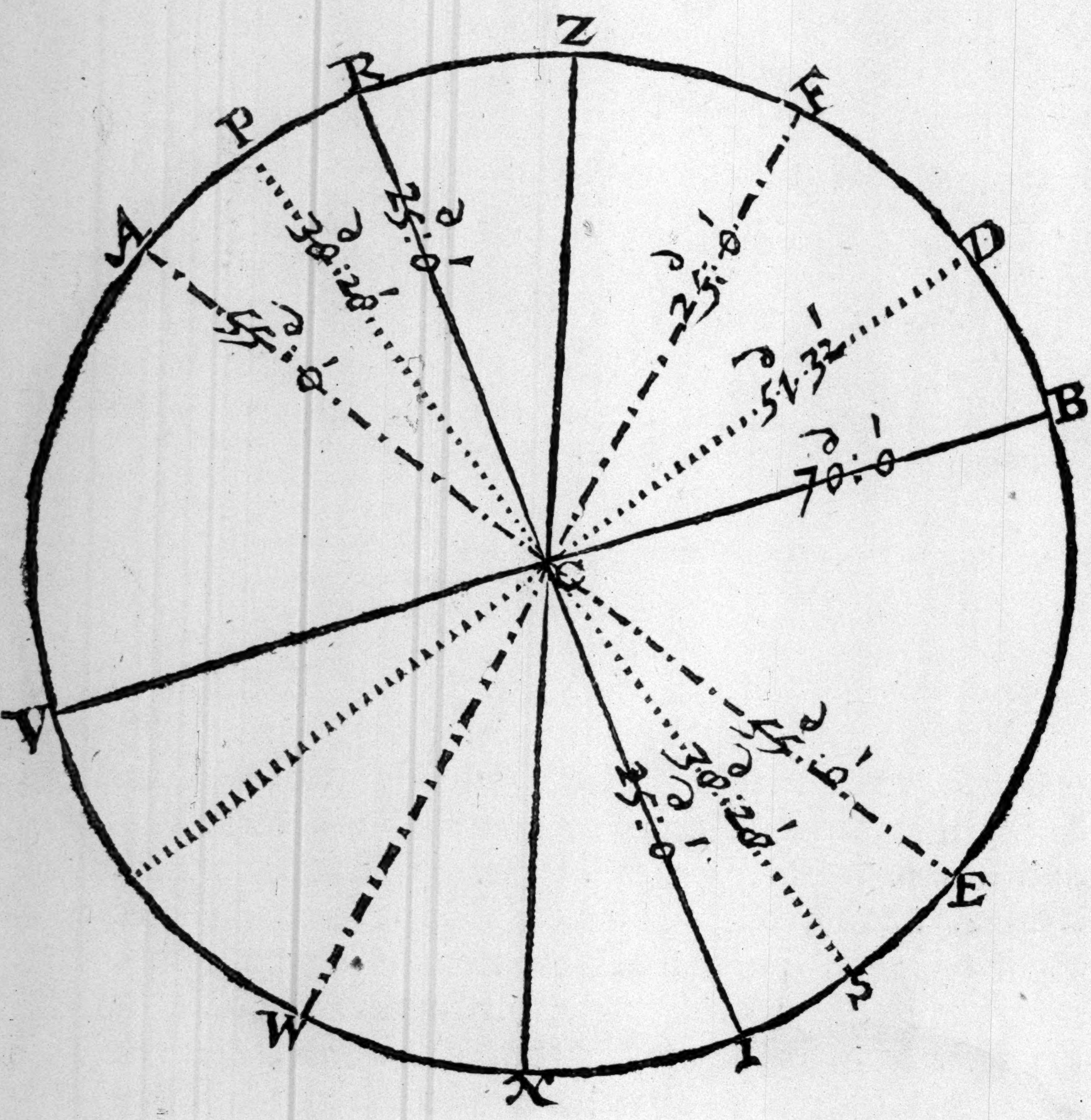
The Demonstration.

The other two prickt circles to the northward of E Z W represent the two reclining planes, *vizt.* E C W reclining 25 d. and E A W reclining 55 d. from the zenith, and are intersected by the houre circles issuing from the pole P, as by inspection of the schem appeareth ; therefore the Dials proper to them have centers, and the poles are elevated above them ; the south pole above the plane E C W ; and the north pole above the plane E A W, which you may note, for directing the stiles : in the first to looke downwards, in the second upwards, according to the rules of the eighth Chapter abovesayd.

Wittekindus and others that follow him, have mistaken the heighth of the stile to this plane reclining 25 d. making it to be 63 d. 28′ high, which should be but 13 d. 28′, and consequently the Diall erroniously made by those directions. For proofe whereof consider this Diagram; therein the limb representing the meridian, the situation of the whole plane in respect of the axis and poles of the world, is more aptly expressed then in the

Data. { Elevation of the pole P N 51 d. 32′.
Reclination Z C 25 d. 0′.

Quæsita. Heighth of the stile P C 13 d. 28′.



former,

former, where the one halfe is alwayes supposed to be under the horizon. Let Z C N be a south plane erect direct; Z representing the zenith, and N the nadir of the place; Z P, N S two arches of the meridian in them, P and S the north and south poles, distant from Z and N the angle Z C P, and N C S 38 d. 28′ the complement of the latitude: and let R C I be the plane reclining 25 d. from Z or N lesse than the pole. It is manifest, that the south pole S is elevated above the plane C I the angle I C S, and so much the north pole P is under the back part thereof R C; therefore taking Z R 25 d. (equall to N I) out of Z P 38 d. 28′ (equall to N S) there remayneth R P 13 d. 28′ (equall to I S) the heighth of the south pole above the plane reclining 25 d. unto which heighth make the Diall in all respects, as you did the horizontall, and you shall have it fit for your plane.

The Arithmeticall calculation.

Returne now to the former schem, therein you have the triangle P C I, or rather taking the circle E D W for the equinoctiall in the quadrantall P D I, you have the whole side P D 90 d. and part thereof P C 13 d. 28′, and the side D I 15 d. of the equator, the measure of the angle P, the first houres distance from the meridian, to finde the side C I upon the plane, *by the first variety of the fift case of R. S. triangles. For,*

		Logar.
As the sine of P D	90^{d} 00′	10000.00
Is to the tangent of D I	15 00	9428.05
So is the sine of P C	13 28	9367.13
To the tangent of C I	3 34	8795.18

This arch of 3 d. 34′ is the distance both of 11 and 1 of clock; and this being all the variety, save increasing the angle at P, I need not reiterate the work, but for imitation sake, have added this canon, and inserted the houres and parts, with their equinoctiall distances, into the Table following, as they follow in order from 12 of clock. For the rest therefore of the houres take out the Log. sine of 13 d. 28′ (the heighth of the stile) into a paper, and adde it continually unto the Log. tangents and

complements

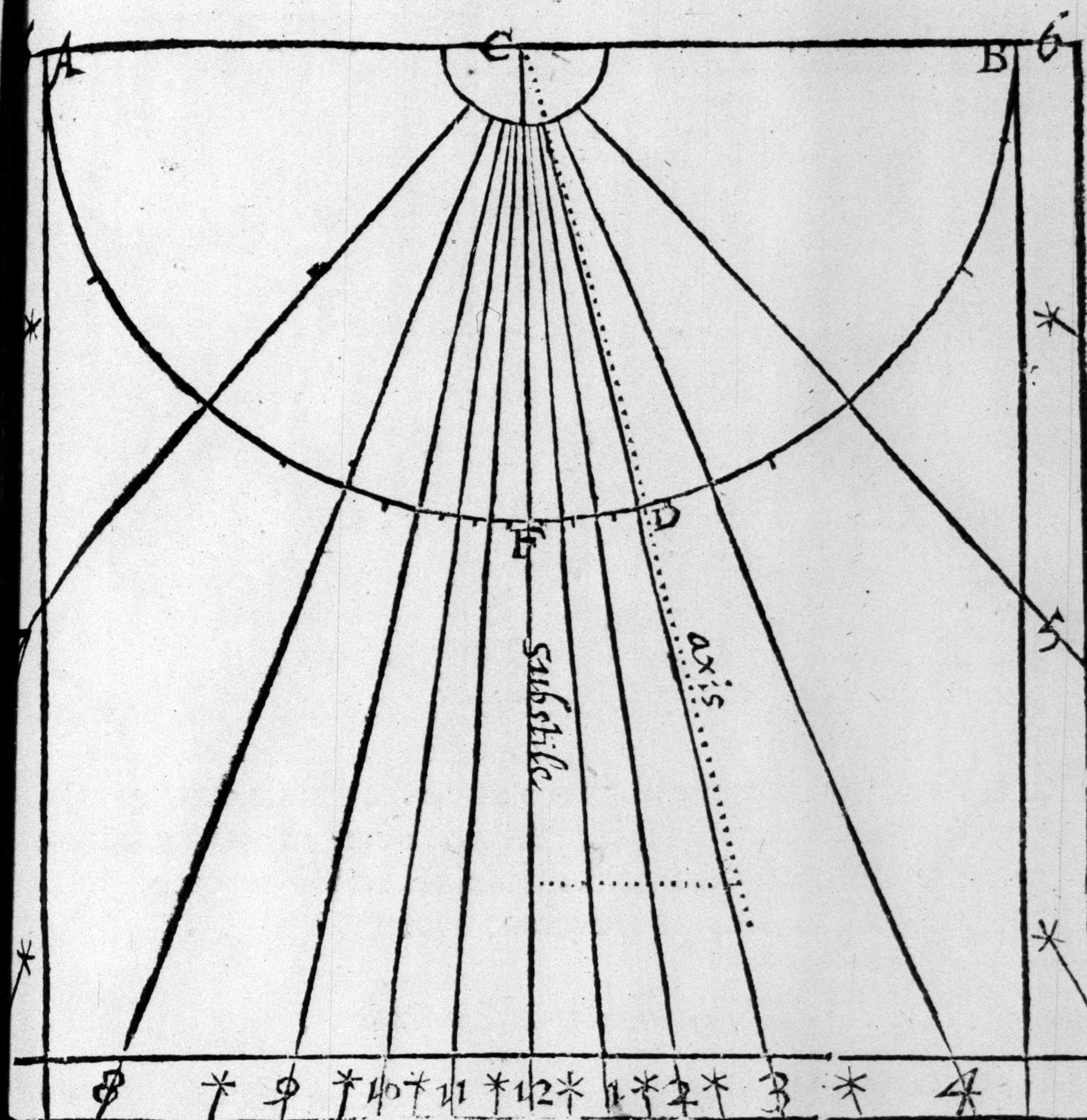
Houres and parts from the merid.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane	Differ.
12	12	d '		d '	d '
	½	7.30	8486.56	1.45	1.49
11	1	15. 0	8795.18	3.34	1.57
	½	22.30	8984.35	5.31	2. 8
10	2	30. 0	9128.56	7.39	2.29
	½	37.30	9252 11	10. 8	2.59
9	3	45. 0	9367.13	13. 7	3.46
	½	52.30	9482.14	16.53	5. 5
8	4	60. 0	9605.69	21.58	7.23
	½	67.30	9749.90	29.21	11.39
7	5	75. 0	9939 07	41. 0	19.31
	½	82.30	10247.70	60.31	
6	6	90. 0	infinite.		

complements of every houres equinoctiall distance, as they stand in the table, so shall you produce other Logar. tangents, which found in the canon, yeeld you arches for the true distances of the rest of the houres upon the plane.

The Geometricall projection.

These arches being thus found, to draw the Diall true, consider the schem, wherein so oft as the plane falleth between Z and P, the zenith and the north pole, the south pole is elevated; in the rest the north; the substile in them all is the meridian, because the prickt circles of the schem (representing the reclining planes) do crosse the meridian thereof N Z S at right angles; wherefore draw the horizontall line A C B for the houre of 6, crosse it at right angles with C F for the houre of 12, upon the center C, and with the length of 60 d. of the chord make the circle A F B, representing the reclining plane of the first schem E C W; from F both wayes towards A and B set on the houre distances of 3 d. 34′ for 11 and 1 of clock, of 7 d. 39′ for

North.



South reclining 25d.

for 10 and 2 of clock, and ſo of the reſt; the forenoon houres on the weſt ſide, the afternoon houres on the eaſt ſide of the meridian, as they lie in the ſchem, from the center C thorow thoſe pricks draw ſtreight lines, as are C 1, C 2, C 3, &c. ſo have you done; by the ſame chord ſet on the heighth of the ſtile 13 d. 28′ from F to D, and draw the prickt line C D, repreſenting the axis of the world, which being erected at the ſame angle, over the ſubſtile C F 12, you have perfected the Diall for a ſouth reclining plane 25 d. as was required: let the houre

houre of 12 be placed upon the meridian, and the whole plane at C raysed to an angle of 65 d. above the horizon, and the axis CD pointing downwards to the south pole; so shall the Diall stand in the due position to receive the shadow of the stile, and give the true houres desired.

The third kinde south reclining more than the pole.

The Demonstration.

For the plane reclining more than the pole, represented in the first schem by the circle E A W, and in the last by A C E, take Z P the complement of the elevation 38 d. 28′ out of Z A the reclination 55 d. and there will remayn P A 16 d. 32′ the heighth of the north pole above the plane; unto which heighth make the Dyall in all respects, as you did the former, only remembring (it being finished) to turne the center downwards, (or draw it so at the first) that the stile being raysed to an angle of 16 d. 32′ upon the meridian line, C E A may point up to the north pole, which is elevated above this plane.

The Arithmeticall calculation.

Instead therefore of the angle P C I in the former schem, now resolve the verticall to it P A 11, *by the first variety of the fist case of R. S. triangles.* For,

			Logar.
As the sine of P A 11	90 d	00′	10000.00
Is to the tangent of A P 11	15	0	9428.05
So is the sine of P A	16	32	9454.19
To the tangent of A 11	4	22	18882.24

This arch of 4 d. 22′ is the true distance of the houres of 1 and 11 from the meridian line; and so are all the rest of the houres calculated, only varying the angle at P.

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5.53
8.15
12.14
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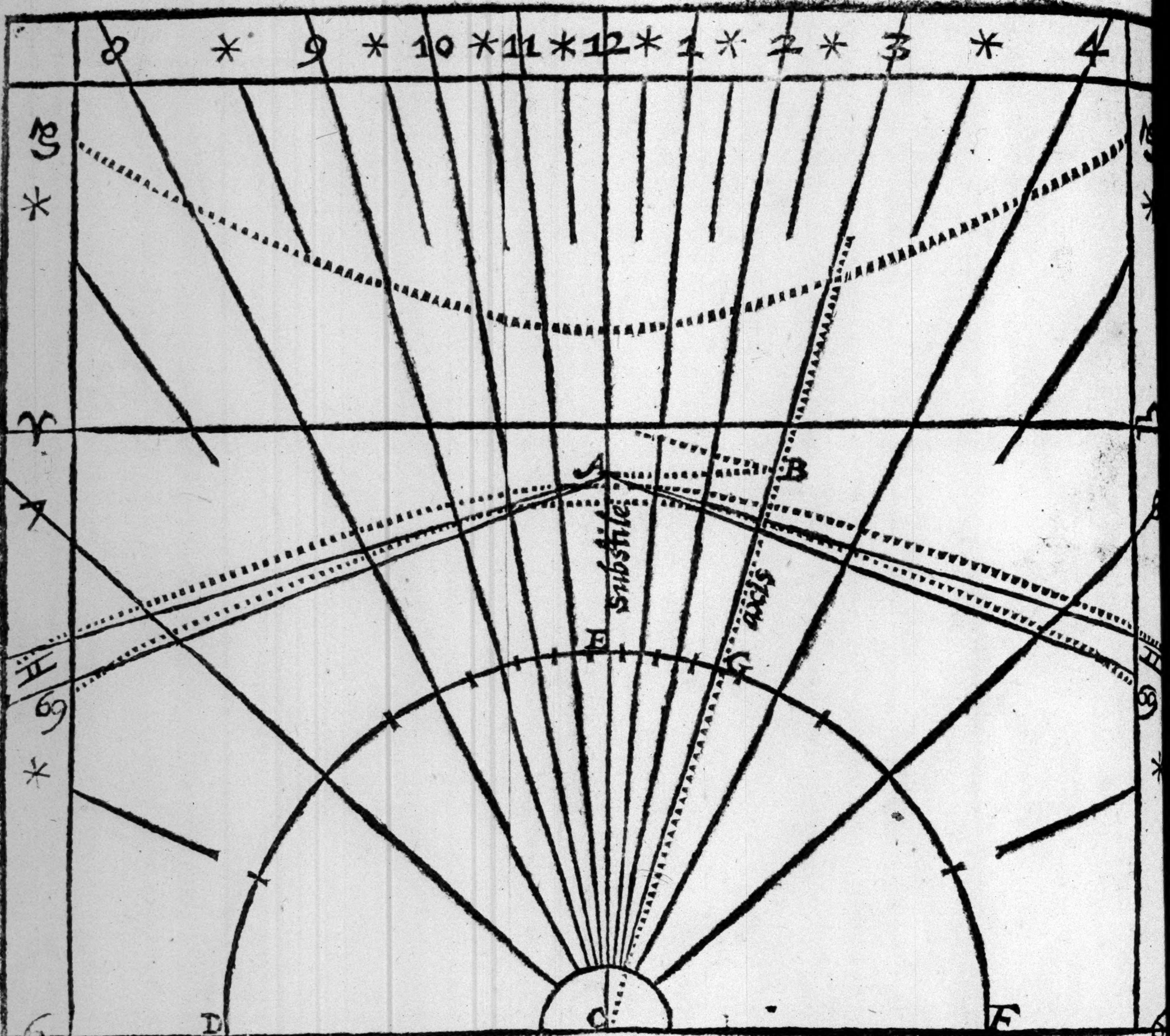
D E F

North



South

South reclining 55 d.

Place this folio 149.

Now therefore make the table as you see done in the example, joyning unto the houres equidistant from 12, their equinoctiall distances, of 7 d. 30′ for halfe an houre, of 15 d. for one houre, &c. then transcribe into a paper *9454.19* the Log. sine of 16 d. 32′ the heighth of the pole or stile above this plane, and adde it continually unto the Log. tangent and complement of each houres equinoctiall distance; so shall you produce new Logarith. tangents, the arches whereof are the true houre distances upon the plane, as appeares in the table.

And these three Dyals thus much south reclining, serve also for their opposites so much north inclining, changing but the numbers of the houres, and respect of the stiles, as the nature of the planes will direct you.

Houres and parts from the merid.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
12	0				
	½	7.30	8573.62	2. 9	
11	1	15. 0	8882.24	4.22	2.13
	½	22.30	9071.41	6.43	2.21
10	2	30 0	9215.63	9.20	2.37
	½	37.30	9339.17	12.19	2.59
9	3	45. 0	9454.19	15.53	3.34
	½	52.30	9569.21	20.21	4.28
8	4	60. 0	9692.75	26.14	5.53
	½	67.30	9836 96	34.29	8.15
7	5	75. 0	10026.13	46.43	12.14
	½	82.30	10334.76	65.10	18.27
6	6	90. 0	infinite.		

The Geometricall projection.

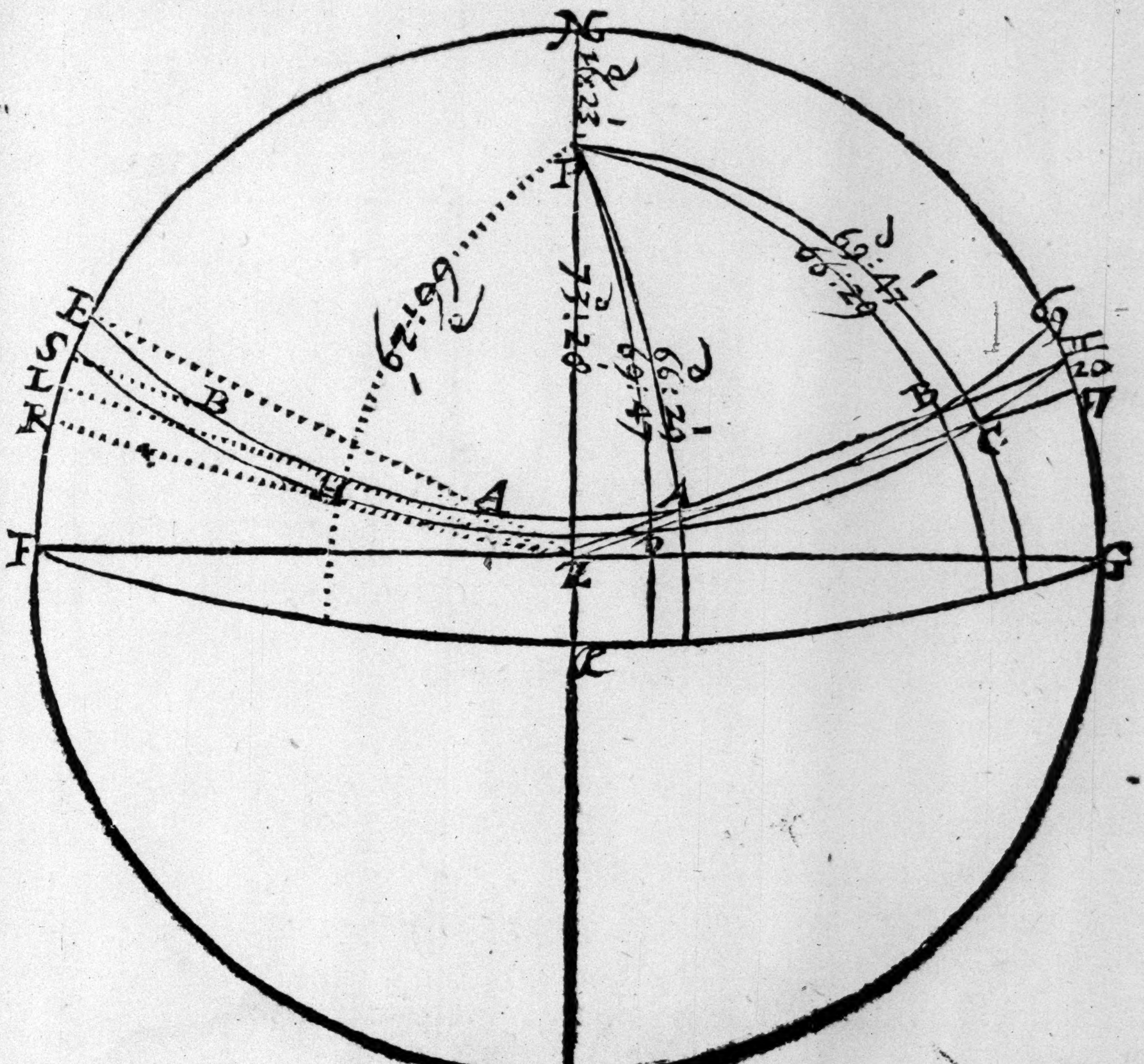
The houre arches being calculated, look back to the schem; let D C F be drawn paralell to the horizon, for the houre of 6; crosse it at right angles with E C for the houre of 12, as E Z W and N Z S do in the schem; upon the center C draw the circle

D E F

DEF (at the extent of 60 d. of the chord) repreſenting the reclining plane in the ſchem E A W, from the point E ſet off the houre diſtances by help of the ſame chord both wayes towards D and E, as you finde them in the table, and from E to G the heighth of the ſtile, and thorow thoſe pricks draw ſtreight lines from C, which ſhall be the houre lines, and axis deſired. Let C G B be erected perpendicularly over the meridian or ſubſtile C E 12 at an angle of 16 d. 32′, and let the whole plane at 12 be rayſed above the horizon an angle of 35 d; then ſhall the axis C B point up to the north pole, and the Dyall bee fitted to the plane.

Now becauſe this plane and Dyall falleth out conveniently for the purpoſe, I thought fit to ſpeak ſomewhat of *Clavius* his conceipt of framing a Dyall, wherein the ſhadow of the ſtile ſhall go backwards and forwards, both forenoon and afternoon: he writes at large of it, with the demonſtration thereof, in his book called *Horologiorum deſcriptio*; wherein hee acknowledgeth the retrogradation of the ſhadow upon the Dyall of *Achaz* to bee moſt miraculous, notwithſtanding that ſo the plane may bee contrived, that at ſome time of the yeere the ſhadow of the ſtile ſhall performe the like in ordinary courſe of nature. The reaſon thereof is plaine, as by the Globe or this ſchem adjoyning may appeare: for ſuppoſing the Globe to be ſet to 16 d. 32′, the heighth of the pole above this plane; and the Sunne to bee in the beginning of ♊, being the quarter of altitude ſet in the due place, unto the ſeventeenth azimuth from eaſt northerly, and you ſhall ſee the paralell of ♊, wherein the Sunne is ſuppoſed to bee to croſſe that azimuth twice before noon, once a quarter before 7 of clock, and againe about 11. Alſo the tropick of *Cancer* to croſſe the twentieth azimuth, once at 7 of clock 10′, and againe about 10 and a quarter, between which two interſections of either paralell you may obſerve the ſhadow of the ſtile apparantly to lengthen and ſhorten according to the diſtance of the Sunne from each of them; ſometimes growing neerer the equator of the Diall, from the interſection of A ♋ to the touch point of A ♊, and ſometimes further off, from the touch point of A ♊ to the interſection of A ♋ againe. The like will be in the afternoone, about

bout the ſame times reſpectively, as the prickt lines in the Dyall croſſing the azimuths of A ♊ and A ♋ do delineat the ſame; and this will continne more or leſſe to be ſeene all the time that the Sunne ſpendeth between the zenith of the plane, and the Tropick of *Cancer*, which will bee from the end of Aprill till towards the end of Iuly following. And note, that fitting the plane for this purpoſe, the like may bee done at all times of the yeere, but beſt neere unto the Tropicks. The proper index to ſhew this conceipt, is a ſtraight pin perpendicular to the plane, as is the prickt line A B in the Dyall, but in a triangular ſtile C A B, the *nodus* or notch cut into it at B ſhall performe the ſame, except you will cut the ſtile ſo ſhort, that the end thereof may ſerve. To make this more plaine, in the diagram adjoyning, let F N G be the horizon, Z P N the meridian, therein P the north pole, elevated 16d. 32′ above the horizon at N, Z the



zenith,

zenith, F E G the equator, E A B ♋ the Tropick of ♋, S H C ♊ the paralell of ♊, Z A B the twentieth azimuth from the prime verticall F Z G, crossing the Tropick of ♋ twice in the forenoon at A and B, and at the like times and places in the afternoon, Z D C the seventeenth azimuth, crossing the paralell of ♊ twice in the forenoon at D and C, and at the like times and places in the afternoon.

Now I would know the heighth of the Sunne and houre of the day in each place, where the Sunne crosseth the paralels of ♋ and ♊, as also where it toucheth the same, to the end I may observe without much attending, this conceipt of *Clavius* upon the Dyall.

From the pole at P draw foure meridians, passing by the double intersection of each paralell and azimuth in the points A B C D, and falling upon the equinoctiall at right angles; first therefore in the oblique triangle P A Z I have the side P Z, the complement of the heighth of the pole 73 d. 28′, and the side P A, the complement of the declination of ♋ 66 d. 29′, and the angle P Z A 70 d. the complement of the azimuth Z A 20 d. from the prime verticall, to finde the side Z A, whose complement A 20, is the heighth of the Sunne in A, *by the eighth case of oblique S. triangles.*

First,

			Logar.
As the sine of	90 d	0′	10000.0000
Is to the tangent of P Z	73	28	10527.4681
So is the cosine of P Z A	70	0	9534.0516
To the tangent of	49	3	10061.5197

Secondly,

			Logar.	
As the cosine of P Z	73 d	28′	0545.8061	*Arith. compl.*
Is to the cosine of	49	3	9816.5065	
So is the cosine of P A	65	29	9600.9901	
To the cosine of	23	13	9963.3027	

Out of 49 d. 3′ take 23 d. 13′, there resteth 25 d. 50′ for Z A, the complement whereof A 20 is 64 d. 10′, the heighth of

6u:10

of the Sunne in A, and added to 49 d. 3′ giveth 72 d. 16′ for Z B, the complement whereof B 20 is 17 d. 44 the heighth of the Sunne in B. Now by two sides and an angle opposite to one of them, you may finde the angle at P opposite to the other side, in each triangle Z P A and Z P B, *by the third case of Ob. S. triangles*, the measures whereof upon the equator F æ G are the houres desired.

		Logar.	
As the sine of P A	66^d 29′	0037.6571	*Ar. compl.*
Is to the sine of P Z A	70 0	9972.9858	
So is the sine of Z A	25 50	9639.2422	
To the sine of Z P A	26 31	19649.8851	

26 d. 31′ converted into time, gives 1 houre, 46 minutes for the houre of the Sunne in A, before or after noon.

		Logar.	
As the sine of P B	66^d 29′	0037.6571	*Ar. compl.*
Is to the sine of P Z B	70 0	9972.9858	
So is the sine of Z B	72 16	9978.8579	
To the sine of Z P B	77 27	19989.5008	

77 d. 27′ converted into time, gives 5 houres, 10 minutes next hand, before or after noon, when the Sunne in B crosseth the azimuth of 20 d. from the prime verticall, and the variation of the shadow to bee performed in 3 houres and 24 minutes.

Lastly, let the azimuth Z H L be drawn to touch the paralell of ♋ in H, and let the meridian P H passe by the touch point thereof, so have you the triangle P H Z right angled at H, whose side Z H shall give the complement of the heighth of the Sunne, and the angle Z P H the houre of the day, when the Sunne in his greatest obliquity from the azimuth Z L, which formerly he crossed in B, commeth back again to crosse the same in A, shortning the shadow from B to H, and lengthning the same from H to A, *by the first of the third case of R. S. triangles*: and *by the first of the fifteenth case of R. S. triangles.*

			Logar.
As the cosine of P H	66^d	29′	9600.9901
Is to the sine of P H Z	90	0	10000.0000
So is the cosine of Z P	73	28	9454.1938
To the cosine of Z H	44	30	9853.2037

Therefore H L 45 d. 30 the heighth of the Sunne.

			Logar.
As the sine of P Z	73^d	28′	9981.6620
Is to the sine of P H Z	90	0	10000.0000
So is the sine of Z H	44	30	9845.6618
To the sine of Z P H	46	59	9863,9998

46 d. 59′ converted into time, giveth 3 houres, 8 minutes before or after noon, when the Sunne in his retrograd motion from H, lengthneth the shadow againe.

And, *by the second of the fifteenth case of R. S. triangles*, you may finde the angle P Z H to be 73 d. 2′, therefore the azimuth Z H L touching the paralell of ♋ is 16 d. 58′ from the prime verticall F Z G, neere the same with Z D C, 17 d, crossing the paralell of ♊ in D and C.

Thus may you also finde for the paralell of ♊.

The heighth of the Sunne { in C 15^d 20′. / in D 75 32.

			ho.	′
The houre of the day	in C	before noon	7	17
		after noon	5	17
	in D	before noon	0	59
		after noon	0	59

The heighth of the Sunne in H 55 d. 26′.

		ho.	′
The houre of the day in H	before noon	9	35
	after noon	2	25

And the variation of the shadow performed in 4 ho. 18′.

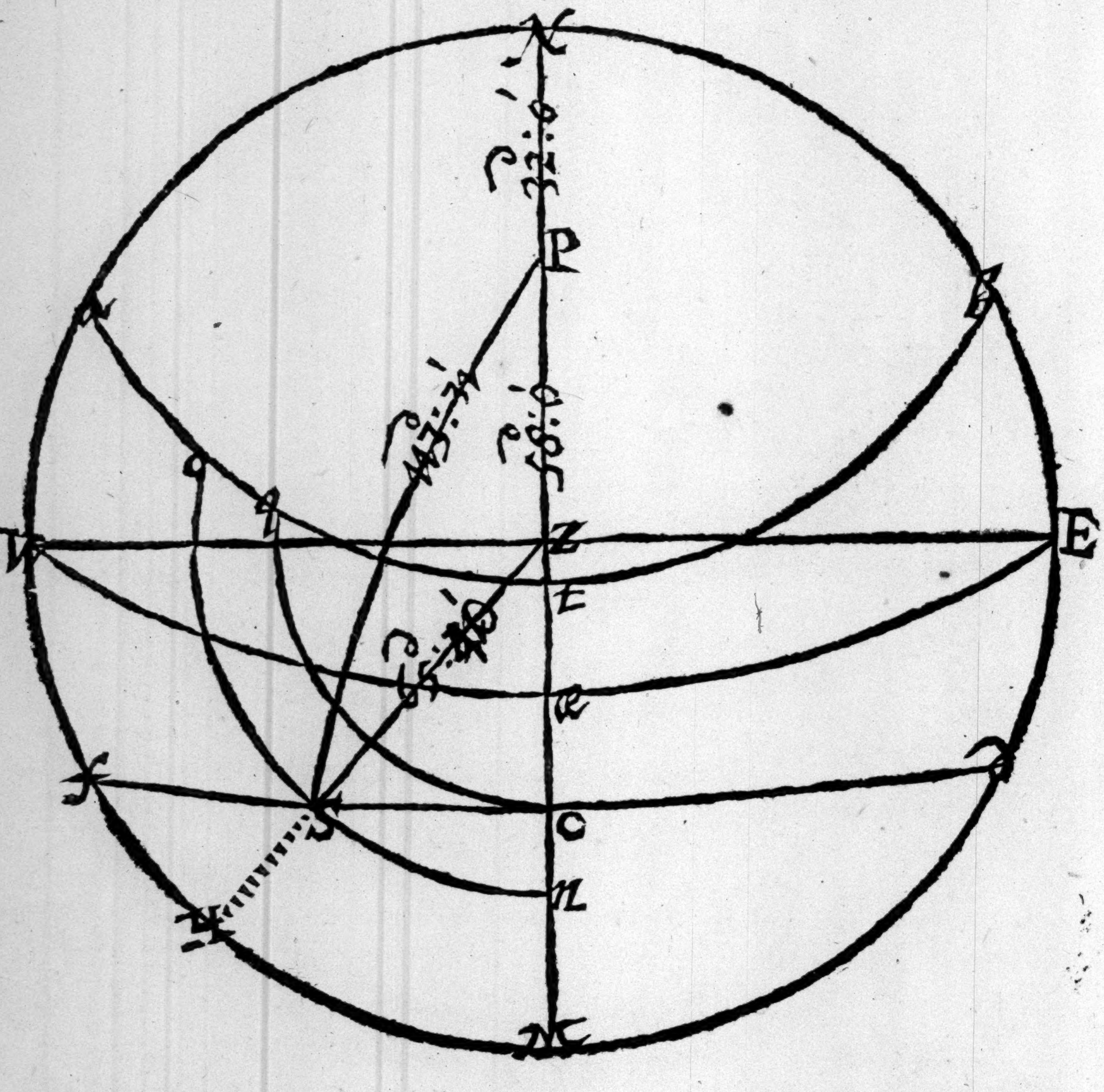
Now if I had drawn the azimuths of Z A B and Z D C to the intersection of each paralell with the horizon, as is Z E for ♋, and Z S for ♊, the retrogradation would have been the more

moreapparant, conteyned between E L for ♋, and S R for ♊, and the times would have differed accordingly, but then the double interſection of the paralell and azimuth would not have been ſo manifeſt, ſeeing one of them hapneth upon the horizon, where the ſhadow vaniſheth ; and note, that the larger the plane is, the more apparant will the retrogradation be.

Some Divines writing upon this miracle, have confined the Dyall of *Achaz* to the equinoctiall plane only, which might be any other as well, and interpret the degrees ſpoken of by the Prophet, to be halfe houres, ſo that 10 d. conteyned 5 houres ; as well they might have made the degrees quarters of houres, and then the ten degrees had been but two houres and a halfe, which is very neere the truth in the matter of time. But ſeeing the Scripture taken in the literall ſenſe, doth ſufficiently manifeſt this wonderfull miracle, I ſee no reaſon to interpret degrees contrary to the uſuall acception of Aſtronomers, and grounds of Art, at the leaſt they could not be meant of halfe houres, becauſe *Hezekiah* had liberty to chuſe whether the ſhadow ſhould go forward ten degrees, or back as much ; but forward it could not go in the latitude of *Ieruſalem,* which is 32 d. becauſe the ſemidiurnall arch of the Sunne in ♑ is but 4 ho. 57′, and in ♋ but 7 ho. 3′, which muſt have been (accompting halfe an houre for a degree) 10 ho. at the leaſt.

My opinion is therefore, that the Dyall was a ſouth Dyall, drawn upon a ſouth erect plane or wall, moſt conſpicuous to every mans view ; that the degrees are literally meant, the degrees of altitude of the Sunne, commonly called almicanters ; that the time of the yeere was neere Chriſtmas, when the Sunne was in the winter tropick of ♑, in which ſigne the ſhadow deſcendeth ſloweſt ; that it was in the afternoon, becauſe the Sunne returned ten degrees which it had gone down ; that the Sunne returned not back at once, but in the ſame time that it had deſcended, to the end that moſt part of the world might take notice of the miracle, as the Scripture teſtifieth the Babylonians did ; and that the Sunne was neere two houres and a halfe returning to the meridian again, from whence it had formerly gone down ; and that the miracle was ſhewed about halfe an houre after two, as may be proved by the diagram fol-

lowing: Therein N E M W the horizon, N P Z M the meridian, E æ W the equator, a t b and f c d the two tropicks, q c and o n two almicanters, P S a meridian, and Z S an azimuth passing by the place of the Sunne in S. The heighth of the pole at *Jerusalem* is P N 32 d, therefore the heighth of the equator æ M 58 d. subtract the declination æ c 23 d. 40′, (about that time neere the middle obliquity) so have you the meridian altitude of the Sunne in ♑ c M 34 d. 20′, abate 10 degrees of the heighth, then was the Sun at the time of the miracle at S 24 d. 20′ above the horizon, the complement whereof S Z is 65 d. 40′; thus have you an oblique triangle P Z S, whose 3 sides are given to finde the angle at the pole, *by the first case of O. S. triangles*, shewing the time that the Sunne hath spent between the meri-



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dian at C, and going down of 10 degrees at S, which by this example was 2 ho. 26′, and consequently the whole day lengthned 4 ho, 52′, which made the shortest day of the yeere equall with the longest.

ZS	65^d	40′		
SP	113	40		
ZP	58	0		
	237	20	*Logar.*	
the ½	118	40	0056.7898	*Ar. compl.*
	53	0	0097.6514	
	5	0	8940.2960	
	60	40	9940.4091	
	Totall		19035.1463	

The halfe whereof 9517.5731 *is the Logar. tangent of* 18*d.* 14′ *halfe the angle at P, therefore the double* 36 *d.* 28′ *is the whole angle, which converted into time, giveth* 2 *ho.* 26′.

Yet lest this conceipt of *Clavius*, which hee also receiveth from *Nonius*, should seeme any thing at all to extenuate the wonderfull power of that miraculous signe, let the difference between them be considered; for in the Dyall of *Achaz* the Sunne it selfe was removed back in the heavens, and therefore the shadow as an effect thereof, which in the paralell motion of the Sunne from east to west was shortned in the afternoon, contrary to the course of nature; but in this conceipt, the shadow continually shortneth in the forenoon, and lengthneth continually in the afternoon; and the Sunne proceedeth continually from east to west, so that all the variety of the shadow is between north and south, quite contrary to the motion of the former. I therefore embrace the conceipt, but wish the comparison had been forborn, since they agree not at all together.

CHAP. XIV.

To draw the houre lines upon any direct north reclining or inclining plane.

THe direct north reclining planes have the same varieties that the south had; for either the plane may recline from the zenith just to the equinoctiall, as E D W doth in the first schem of the last Chapter, and then it is a polar plane, (as I called it before) because the poles of that plane lie in the poles of the world: or else the plane may recline more or lesse than the equinoctiall, as the circles E F W and E B W do, and consequently their poles fall above and under the pole of the world, and the houre lines also differ from the former.

The Demonstration.

The polar Diall is well known to all men to be no more but a circle divided into 24 equall parts, which, because the zenith is to the horizon as the pole of the world is to the equinoctiall, may bee easily contrived upon the first schem of the former Chapter, by dividing the limb into 24 equall parts. Suppose therefore that from the center Z you draw streight lines to every 15 d. (the twenty fourth part of the horizon) and the Dyall is made.

The Geometricall projection.

To contrive this Dyall upon the plane, draw two streight lines H V A for the houre of 12, and 6 c 6 for the houre of 6, crossing each other at right angles in C, representing N Z S the meridian, and E Z W the prime verticall of the schem; upon the center C, with the radius Z S of the schem (equall to 60d. of the chord) draw the circle ♍ A ♉, representing the limb of the schem N E S W, take off the same chord 15 d. which set

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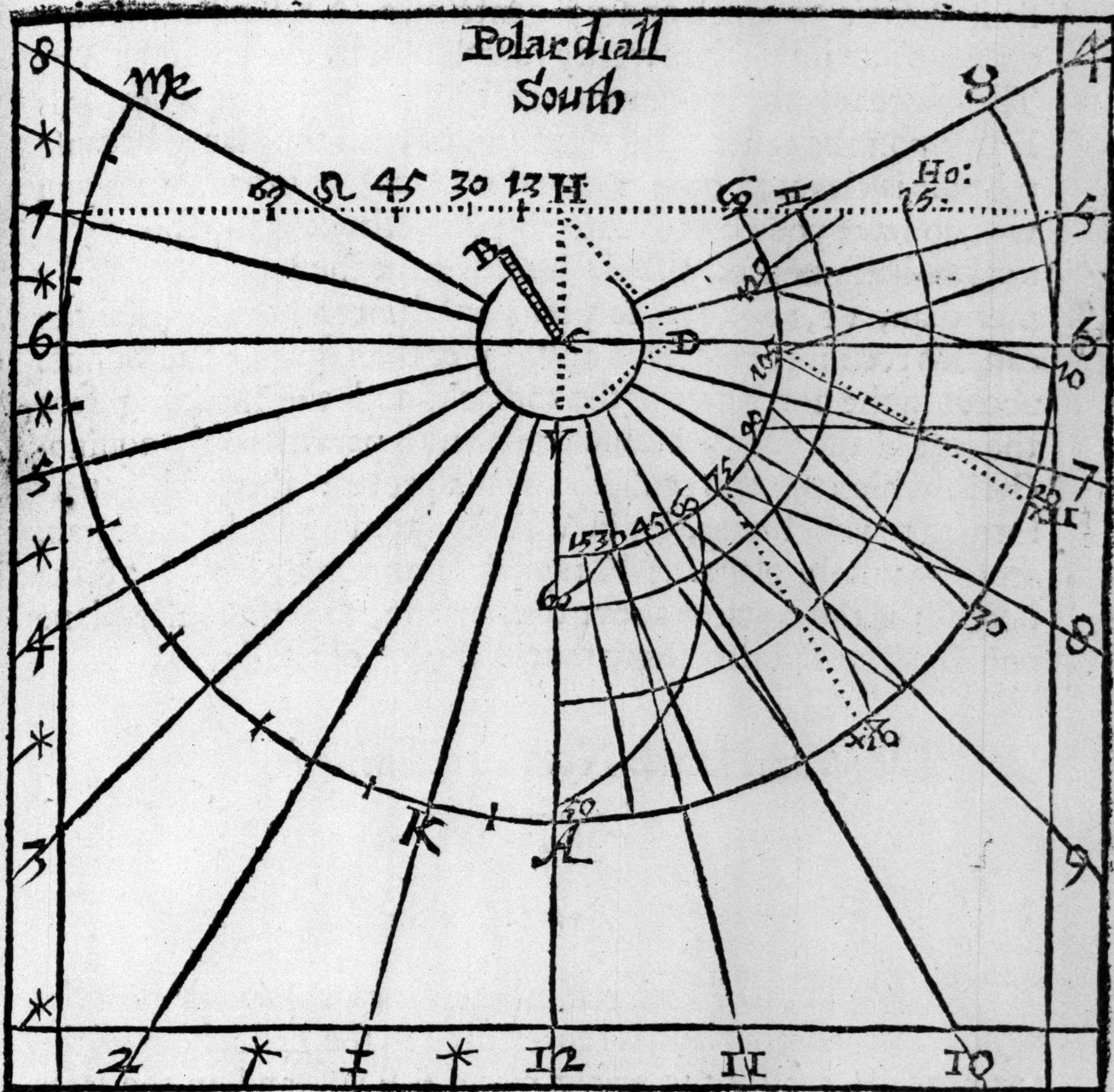


both wayes from A, will divide the ſayd circle into 24 equall parts, (ſuch as A K is one) thorow which ſtreight lines being drawn from the center C, are the houre lines deſired; and theſe being contracted or enlarged according to the capacity of the plane, the Dyall is made greater or leſſer at pleaſure; but if you like not to be alwayes confined to the ſame chord, you may draw a circle upon the plane at adventure, and by the laſt precept of the firſt Chapter, ſpeedily ſet out the houre diſtances thereon; for ſuch proportion as the ſine of 30 d. hath to the ſine of 7 d. 30′, halfe the houre arch, ſuch hath the radius of the

circle in parts, to the twenty fourth part of the circle desired. So if A C be one inch and 77 centesmes, A K shall be 46 centesmes of an inch, the twenty fourth part of the circle ♍ A ♉. The houre lines being drawn, erect a streight pin or wyer, as is B C, upon the center C at right angles with the plane (because the pole is elevated 90 d. above this plane) of what length you will, so have you done; yet seeing our latitude is capable but of 6 houres and a half ~~sixteen halfe houres~~, the six houres next the south part of the meridian, 11, 10, 9, 1, 2, & 3 may be left out as uselesse; neither can this reclining face serve any longer than during the Sunnes aboad in the north part of the zodiack, and the inclining face the rest of the yeere, because this plane is paralell to the equinoctiall, which the Sun crosseth twice a yeere: these things performed to your liking, let H V A be placed upon the meridian, and the whole plane at H raysed to an angle of 38 d. 28′ the heighth of the equator above the horizon, so is this polar plane and Dyall rectified to shew the true houre of the day.

The second kinde North reclining lesse than the equator.

The Demonstration.

The next sort is of such reclining planes as fall between the zenith and equator, and is represented in the first schem of the former Chapter by the prickt circle E F W, and in the later schem by F C W, both supposed to recline 25 d. from Z the zenith. Ad therfore unto P Z 38 d. 28′ the compl. of the elevation, Z F 25 d. the reclination, so have you PF 63 d. 28′, the heighth of the pole or stile above this plane. In this Dyall also *Wittekindus* and others that follow him are mistaken, directing the reclination to be taken out of the elevation, and the remainder reserved for the heighth of the pole or stile, (which in their owne example doth substitute 7 d. instead of 83 d.) whereas they should adde the reclination to the complement of the elevation, as by the schem appeareth, and as in this example is done.

The

The Arithmeticall calculation.

To calculate the houre lines true, returne to the first schem of the former Chapter. In the triangle P F I, or rather the quadrantall P D I as afore, you have P D 90 d, and P F 63 d. 28′, and D I 15 d. the measure of the angle at P given, to finde the side F I, the first houres distance from the meridian upon the plane, *by the first variety of the fift case of R. S. triangles.*

			Logar.
As the sine of P D	90^{d}	0′	10000.00
Is to the sine of P F	63	28	9951.66
So is the tangent of D I	15	0	9428.05
To the tangent of F I	13	29	~~1~~9379.71

This 13 d. 29′ is the true houres distance of 11 and 1 of clock, and seeing there is no other variety, (but increasing the angle at P) in seeking the rest of the houre distances, it is needlesse to repeat the work, but referre you to the table adjoyning; wherein (as often heretofore directed) first set downe all the houres from 12 and their parts.

Houres and parts from the merid.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
12	12				
	½	7.30	9071.09	6.44	6.46
11	1	15. 0	9379.72	13.29	6.51
	½	22.30	9568.89	20.20	6.59
10	2	30. 0	9713.10	27.19	7. 9
	½	37.30	9836.64	34.28	7.21
9	3	45. 0	9951.66	41.49	7.34
	½	52.30	10066.68	49.23	7.47
8	4	60. 0	10190.23	57.10	7.59
	½	67.30	10334.44	65. 9	8.11
7	5	75. 0	10523.61	73.20	8.18
	½	82.30	10832.23	81.38	8.22
6	6	90. 0	infinite.		

Data	Elevation of the pole	DN	51^d	32′.
	Reclination ———	ZF	25	0
Quæsita	Heighth of the ſtile	DF	63	28

Next ſet the equinoctiall diſtances by them, as to 11 and 1, 15 d, to 10 and 2, 30 d. &c. then take into a looſe paper the Log. ſine of P F in the ſchem 63 d. 28′, 9951.6651, the elevation of the pole above this plane, which added continually unto the Log. tangents and complements of every houres equinoctiall diſtance, giveth new Logarith. tangents, whoſe arches are the true houre diſtances (upon the plane) deſired, as in the table appeareth; which done, the Dyall is to be made in all reſpects like the horizontall.

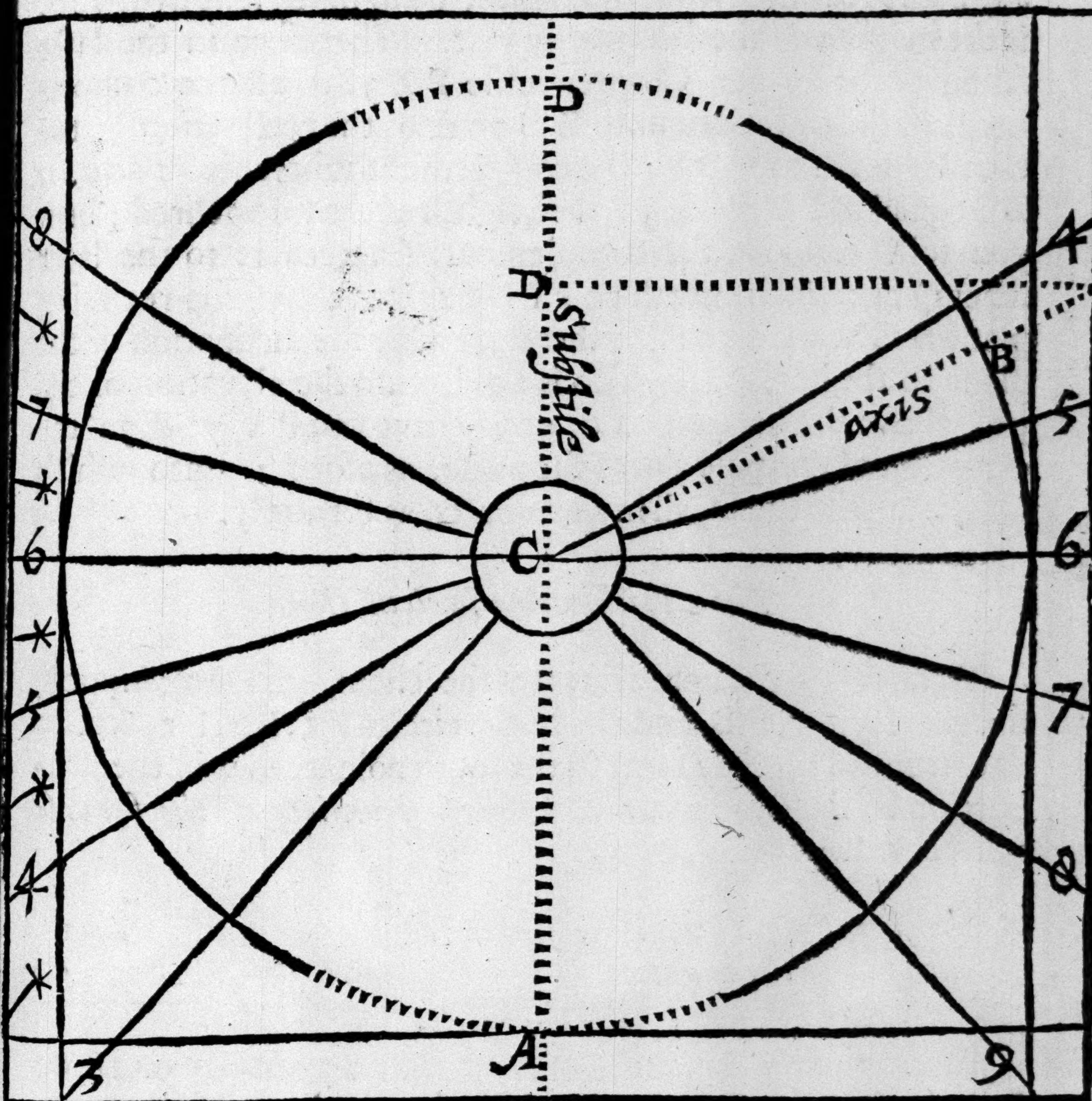
The Geometricall projection.

Draw therefore the horizontall line 6 C 6, croſſe it at right angles with D C A; upon the center C (at the diſtance of 60d. of the chord) make the circle D B A, repreſenting the reclining plane E F W in the ſchem; ſet off the houre diſtances (by help of the chord) both wayes from A, the north part of the meridian, as they are calculated in the table, *vizt.* for 9 and 3, 41 d. 49′, for 8 and 4, 57 d. 10′, for 7 and 5, 73 d. 20′, &c. from the center C thorow thoſe pricks draw ſtreight lines, and they ſhall be the true houre lines deſired; continue 7 and 8, and 5 and 4, thorow the center to the oppoſite parts, ſo have you the ſame houres above the 6 of clock line alſo; this done, with the ſame chord ſet 63 d. 28′ from D to B, draw the line C B for the heighth of the ſtile: let the ſouth part of the Dyall at D ſtand upwards upon the plane, elevated to 65 d. above the horizon, that the ſide C B of the ſtile being perpendicularly erected over the ſubſtile line C D, may reſpect the north pole, ſo have you done; the houres about the meridian, *vizt.* 11 and 1, and 10 and 2, can never receive any ſhadow, becauſe of the ſmall reclination of the plane from the zenith, and therefore needleſſe to put them on. For more particular proofe whereof, I referre you to the fourth propoſition in the thirty ~~fourth~~ fifth Chapter; but what-

whatſoever is defective in the reclining ſide, will bee ſupplied in the oppoſite inclining ſide, upon which the Sunne ſhineth as ſoone as it forſaketh the other.

North reclining 25 d.

South.



North.

The third kinde North reclining more than the equator.

The Demonſtration.

The laſt ſort is of ſuch reclining planes as fall between the horizon

horizon and equator, repreſented in the firſt ſchem of the former Chapter, by the circle E B W, but in the later ſchem by B C V, ſuppoſed to recline 70 d. from the zenith.

Now the equator cutting the axis of the world at right angles, all planes that are paralell thereto have their ſtiles elevated 90 d. above the plane; and by how much more than the equator any plane reclineth from the zenith, by ſo much leſſe than 90 d. is the heighth of the ſtile proper to it. Therefore in the later ſchem of the former Chapter adde P Z 38 d. 28′ the complement of the elevation, unto Z B 70 d. 0′ the reclination; the totall is P B 108 d. 28′, the complement whereof to 180 d. is B S equall to P V 71 d. 32′ the heighth of the ſtile deſired; or if you will without the complement, (agreeable to the later ſchem) becauſe the north pole P is elevated above the reclining plane B C V, the arch P V; therefore adde the inclination of the plane to the horizon, which is 20 d. unto the elevation of the pole above the horizon 51 d. 32′, ſo have you P V 71 d. 32′ the elevation of the pole above the plane, as afore; unto which heighth make the Dyall in all reſpects, as formerly.

The Arithmeticall calculation.

To calculate the houre lines by the ſchem, you muſt ſuppoſe the meridian P F B, and the houre circles P 1, P 2, P 3, &c. to be continued till they meet in the ſouth pole, then will the proportion be the ſame as afore, *by the firſt variety of the fift caſe of R. S. triangles.*

	d.	′	Log.
As the ſine of P D, counting from the ſouth pole to the equator	90	0	10000.00
Is to the tangent of D 1, one houres diſtance upon the equator	15	0	9428.05
So is the ſine of P B, counting from the ſouth pole to the plane	71	32	9977.04
To the tangent of B 1, the firſt houres diſtance upon the plane	14	16	9405.09

And this being all the variety of the calculation, we need not reiterate

reiterate the work; now therefore begin the table as you did in the former, setting to every houre equidistant from 12, the equinoctiall distances of 15 d. 30 d. 45 d. &c. proper unto them; then take into a paper the Logar. sine of the heighth of the stile 71 d. 32′ 9977.04, which being continually added unto the Log. tangents of 15 d. and 75 d. for 11 and 5 of clock, of 30 d. and 60 d. for 10 and 4 of clock, &c. shall beget new Log. tangents, the arches whereof are the true houre distances upon the plane, as you see in the example.

Houres and parts from the merid.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
12	0	d ′		d ′	d ′
	½	7.30	9096.47	7. 7	
11	1	15. 0	9405.09	14.16	7. 9
	½	22.30	9594.26	21.27	7.11
10	2	30. 0	9738.58	28.43	7.16
	½	37.30	9862.02	36. 3	7.20
9	3	45. 0	9977.14	43.30	7.26
	½	52.30	10092.06	51. 2	7.32
8	4	60. 0	10215.70	58.41	7.39
	½	67.30	10359.81	66.25	7.44
7	5	75. 0	10548.98	74.14	7.49
	½	82.30	10857.61	82. 6	7.52
6	6	90. 0	infinite.		7.54

Data { Elevation of the pole P N 51^{d} 32′.
{ Reclination ———— Z B 70 0

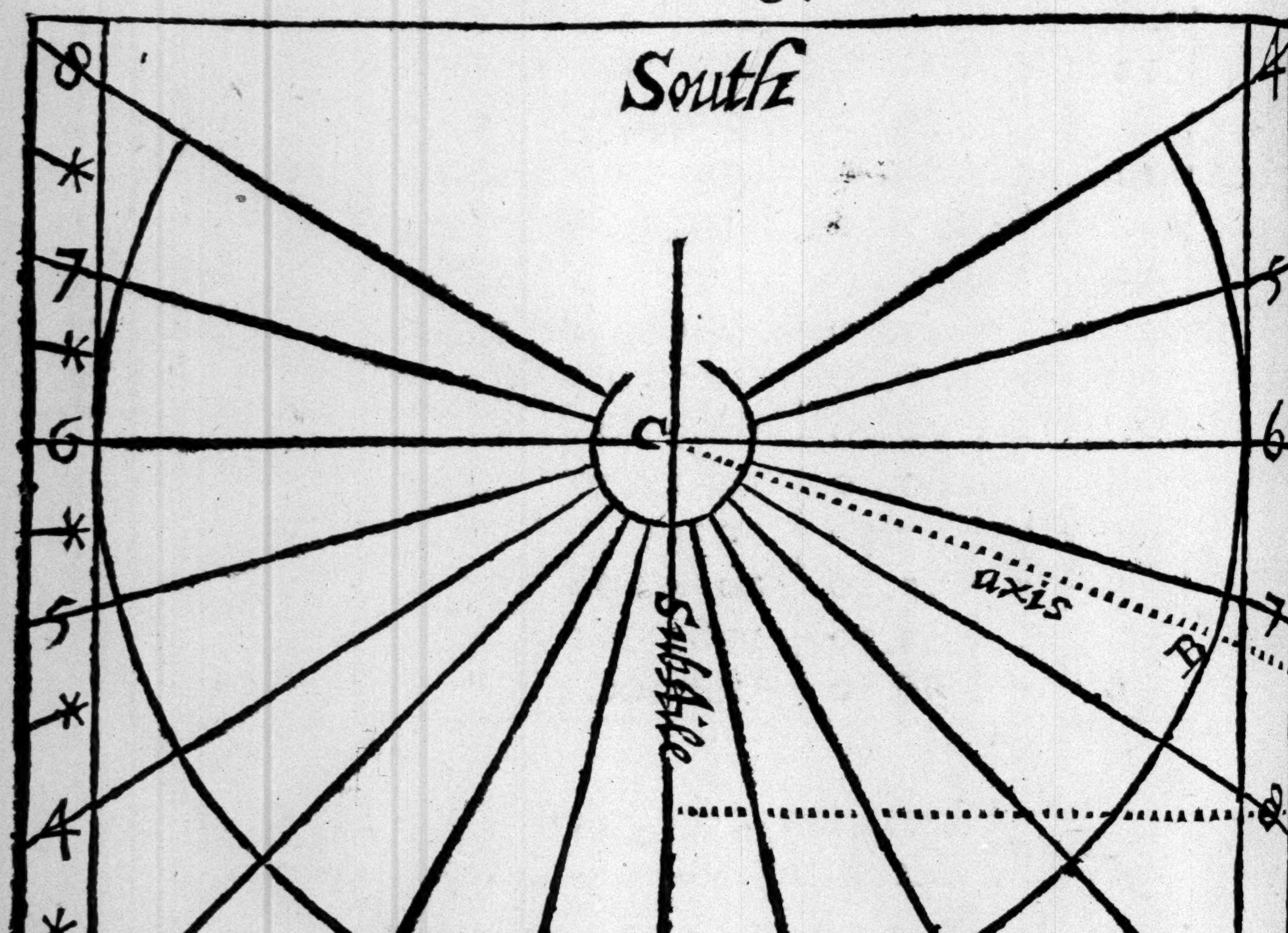
Quæsita Heighth of the stile P B or P V 71^{d} 32′.

The Geometricall projection.

This done, draw two streight lines, C A 12, and 6 C 6, crossing at right angles in C: upon the center C (with 60 d. of the chord) make the circle 6 A 6, representing the reclining plane of the schem E B W, upon which circle the houre arches taken

taken out of the table, and prickt down both wayes from A (by help of the chord) and unto those pricks streight lines being drawn from the center C, you have the true houre lines desired; by the same chord set off the heighth of the stile from A to B, *vizt.* 71 d. 32', and draw the prickt line C B, representing the axis: erect C B at right angles over the substile C A 12, which placed in the meridian line, the center C respecting the south, and the whole plane at C elevated to an angle of 20 d. above the horizon, that the axis C B may point up to the north pole, you have finished the Diall to the plane proposed. And

North reclining 70 d.



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you may further note, that becauſe the reclination of this plane from the zenith is leſſe than the reclination of the tropick of ♑, which is 75 d. 3′, therefore after the Sunnes ſouth declination is 18 d. 28′, (as appeares in the fourth propoſition of the thirty fourth Chapter) it paſſeth off this ſide of the plane, to the oppoſite part, upon which the reſt of the yeere is ſupplied.

Laſtly, as all other planes have two faces, reſpecting the contrary parts of the heavens, ſo alſo have theſe recliners ſix oppoſite ſides looking downwards to the nadir, as theſe looke upwards to the zenith; therefore may you by the very ſame rules make all the inclining Dyals alſo; or if you will ſpare that labour, and make the ſame Dyals ſerve for the oppoſites, turne the centers of the incliners downwards, which were upwards in the recliners, and thoſe upwards in the incliners which were downwards in the recliners; and after this converſion, let the houres on the right hand of the meridian in the recliner become on the left hand in the incliner, and contrary, ſo have you done what you deſired: and this is a generall rule for the oppoſite ſides of all planes, which ſhall bee made more manifeſt in the 21 and 22 chapters, where I purpoſely treat of inclining planes.

CHAP. XV.

To draw the houre lines upon a declining reclining, or declining inclining plane.

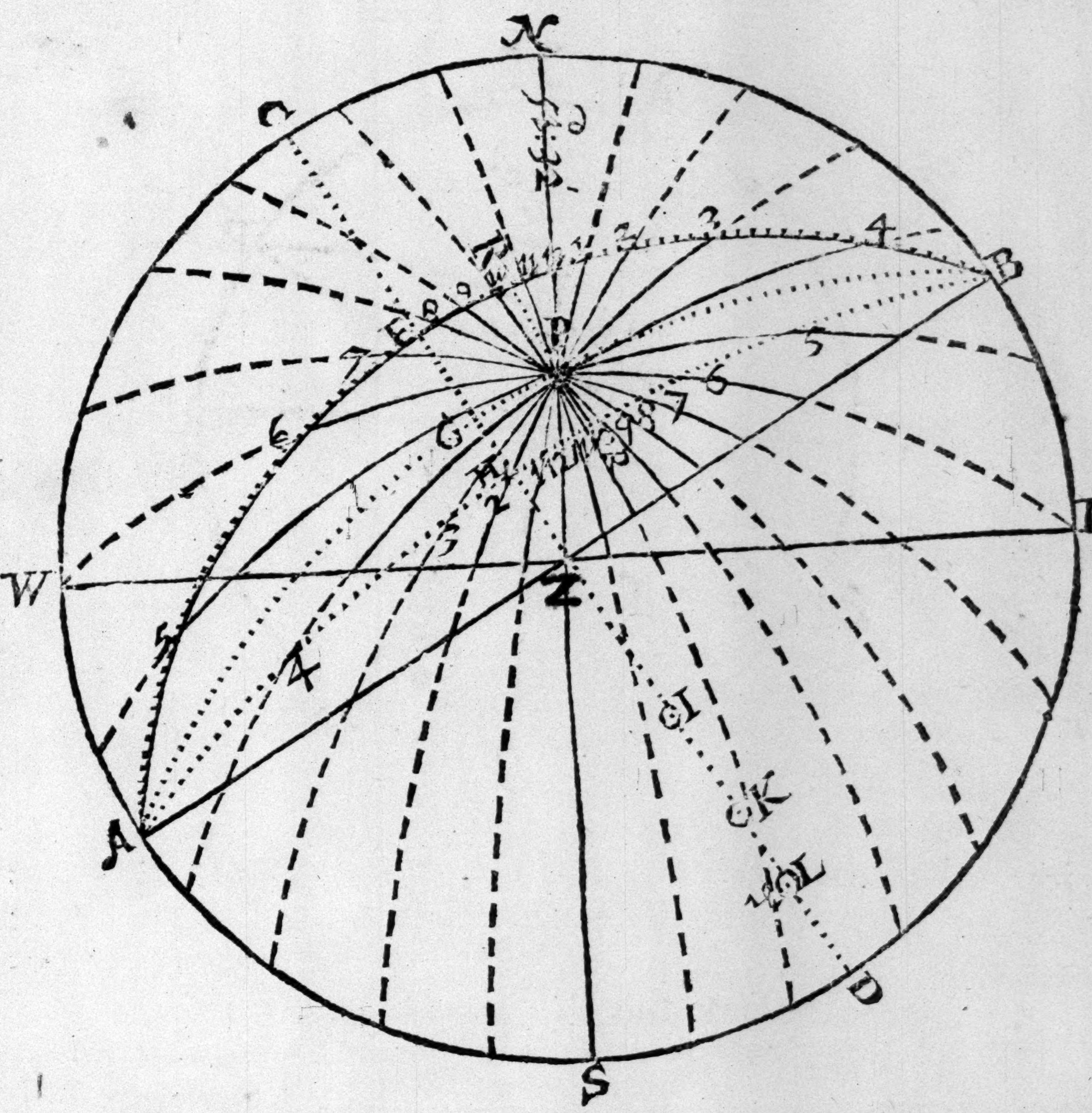
IN declining reclining planes, there be the ſame ſix varieties that were in the former reclining north and ſouth; for either the declination may bee ſuch that the reclining plane will fall juſt upon the pole, and then it is called a declining equinoctiall; or it may fall above, or under the pole, and then it is called a ſouth declining eaſt and weſt recliner: on the other ſide the declination may bee ſuch, that the reclining plane ſhall fall juſt upon the interſection of the meridian and equator, and then it is called a declining polar;

lar; or it may fall above or under the ſaid interſection, and then it is called a north declining eaſt and weſt recliner: of all which I will give particular examples, that by imitation of them nothing may remayn doubtfull.

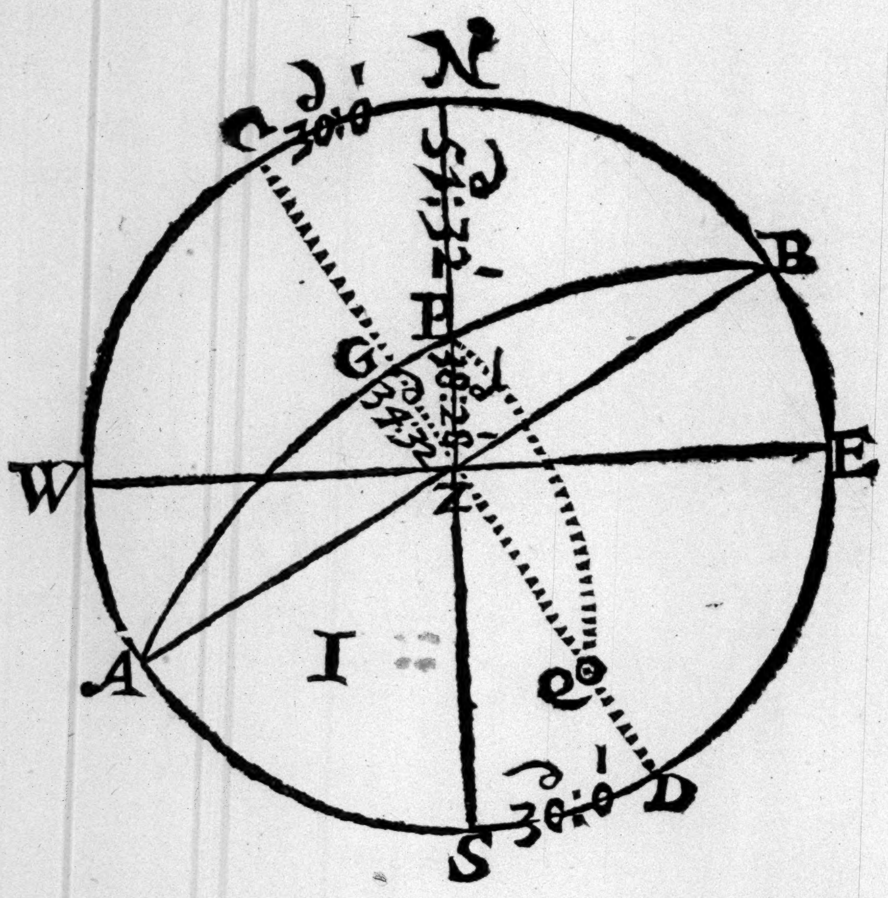
And firſt for the better underſtanding of the work, you may remember that every declining reclining plane hath both a baſe and flat; the baſe perpendicular, but declining, therefore (as afore) ſituate under ſome azimuth or other; and the flat reclining, which to the common mans underſtanding is beſt repreſented by the roofe of a houſe, falling back from the perpendicular of the wall whereupon it ſtandeth; but upon the ſphere by the circle of poſition (as afore) ſuppoſed to move upon the horizon, with the declining baſe, and to fall from the zenith either wayes upon that azimuth which cutteth the baſe at right angles, by reaſon whereof the pole of the reclining circle is alwayes ſo much elevated above the horizon as the circle it ſelfe (repreſenting the plane) reclineth from the zenith: all which may be plainly ſeen in the ſchem following.

The Demonſtration.

Let the baſes of the recliners bee repreſented by A Z B declining from the eaſt point E 30 d. to B as much as the poles thereof C and D do decline from the north and ſouth parts of the meridian N and S. The three varieties of ſouth recliners upon the ſame baſe, are repreſented by the three prickt circles A H B falling between the pole of the world and the zenith, A G B juſt upon the pole, and A E B between the pole and horizon, and the particular pole of each plane is ſo much elevated above the horizon, (upon the azimuth D Z C croſſing the baſe at right angles) as the plane it ſelfe reclines from the zenith, and marked in the ſchem with I K and L. Now to avoyd confuſion of lines, it will not be amiſſe to draw theſe three caſes ſeverally, that you may the more diſtinctly perceive what you are to finde in each of them.



In the first, the declining Æquinoctiall is represented, whose base A Z B declineth 30 d. from the East and West line E Z W, equall to the declination of the South pole therof, 30 d. from the South part of the Meridian S easterly unto D, the reclining plane is AG B, reclining from the Zenith Z upon the Azimuth C Z D, the quantity of Z G 34 d. 32′: and passeth thorough the pole P: Set off from D to Q: the reclination Z G; and Q shall represent the pole of the reclining plane: so much elevated above the horizon at D, as the circle A G B, representing the plane, declineth from the Zenith Z; from the pole of World P to the pole of the plane Q, draw an arch of a great circle P Q: whose centre will fall upon the periphery of the reclining plane, seeing



it cuts the same at right angles in P; And because some may be desirous to any declination giuen, to fit a plane reclining just to the pole: or any reclination being given to find the declination proper to the same, this Diagram will satisfie them therein. In the triangle Z G P, or rather the Quadrantall G C B, let D S or C N the declination be given, and P N the elevation of the pole: to find the arch C G, whose complement is the reclination G Z, *by the first varietie of the 16 case of R.S. Triangles.*

		Logar.
As B N the Cosine of N C the declination	30^d 0′	9937.53
Is to the sine of B C	90 0	10000.00
So is the tang. of N P the height of the pole	51.32.	10099.91
To the tangent of C G	55.28.	10162.38

Whose complement is G Z 34^d 32′ *the reclination desired.*

And by the converse for the other part:

As

		Logar.
As C G the cotangent of the reclination	34 d 32′.	10162.38
To N P the tangent of the elevation	51 32.	10099.91
So is the sine of C B	90. 0	10000 00
To the sine of N B	60. 0	9937. 53

Whose complement N C 30 d. is the declination desired.

The Arithmeticall Calculation.

1 In this first example, you are to find two things: first, the arch of the plane or distance of the Meridian and Substile from the Horizontall Line; which in this Scheme is P B, the intersection of the reclining plane with the Horizon, being at B. And secondly, the distance of the Meridian of the place S Z P N from the Meridian of the plane P Q: which being had, the Diall is easily made; wherefore in the Triangle Z G P right angled at G you have the side G Z given 34 d. 32′ the reclination; and you have Z P given 38 d. 28′ the complement of the elevation; and the angle at Z 30 d. whose measure is N C the declination; to find G P, whose complement is P B, either by the small Triangle Z G P, or by the quadrantall Z C N, *by the variety of the first, third, fourth, or fifth Cases of R. S. Triangles:* or againe if you will (such is the variety of Triangles) by the small Triangle P N B, or the quadrantall B C G, you may without the complement find P B your desire.

		Logar.
1 *As the sine of Z G P*	90 d. 0′	10000.00
Is to the sine of P Z	38. 28.	9793.83
So is the sine of G Z P	30. 0.	9698.97
To the sine of G P	18. 7	19492.80
Whose complement is P B	71. 53	

Or againe in the Triangle P N B you may find P B without seeking the complement, *by the first of the eighth case of R. S. Triangles.*

		Logar.
As the sine of the angle N B P	55d. 28'.	9915.82
Is to the sine of the side P N	51.32.	9893.74
So is the sine of the angle P N B	90. 0.	10000.00
To the sine of the side P B	71. 53.	9977.92

The distance of the Meridian and Horizon.

The second thing to be found is the distance of the Meridian of the place, which is the houre of 12, from the Substile or Meridian of the plane, which is the angle it selfe of the two Meridians, represented by Z P Q; in which point *Wittekindus* and others following him were also mistaken: making the angle of declination to be the distance betweene the two Meridians; by which errour, putting the 12 of clocke line out of the true place, all the rest of the houres by consequent are erroneous also.

To find this angle Z P Q, you must first find the angle Z P G, which taken out of G P Q 90 d. leaveth the angle Z P Q *by the second of the fifteenth case of R.S. Triangles.*

		Logar.
2 *As the sine of the side P Z*	38d. 28.	9793.83
Is to the sine of the angle Z G P	90 0	10000.00
So is the sine of the side Z G	34.32.	9753.49
To the sine of the angle Z P G	65.41.	9959.66

Take the angle Z P G 65 d. 41' out of G P Q 90 d. there resteth Z P Q 24 d. 19' for the difference of Meridians, which gives the distance of 12 of clock from the Substile; or againe, *by the second of the second case of R. S. Triangles.*

		Logar.
As the Radius	90d. 0'.	10000.00
Is to the sine of the latitude	51.32.	9893.74
So is the tangent of the declination	30. 0.	9761.44
To the tangent of the angle betweene the two Meridians.	24.19.	9655.18

Now

Now becauſe 24 d. 19′ is more then 15 d., one houres diſtance from the Meridian: and leſſe then 30 d. two houres diſtance; I conclude that the Subſtile ſhall fall betweene 10 and 11 of clocke, on the Weſt ſide of the Meridian: becauſe the plane declineth Eaſt; and as the very Scheme it ſelfe directeth, being inverted, or drawne to the South pole, as indeed it ought to be.

Data
- Elevation of the pole P N — $51^{d}. 32'$.
- South
  - Declining Eaſt S D or C N — 30 0.
  - Reclining Z G — 34. 32.

Quæſita
- 1 length of the ſtile ——— E F -- 0 2957,
- 2 diſtance of the Horizon & Meridian - P B - 71 d. 53
- 3 angle betweene the Meridians — Z P Q - 24. 19.

Houres and parts from the ſubſtile.		Equinoctiall diſtances.	naturall tang. or the houre diſtances upon the plane.		Houres and parts from the ſubſtile.		Equinoctiall diſtances.	naturall tang. or the houre diſtances upon the plane.	
		d ′					d ′		
.	½	.1.49	.0	032	10	2	.5.41	.0	009
11	1	.9.19	.0	164	.	½	13.11	.0	234
.	½	16.49	.0	302	9	3	20.41	.0	377
12	12	24.19	.0	452	.	½	28.11	.0	536
.	½	31.49	.0	620	8	4	35.41	.0	7[illegible]8
1	11	39.19	.0	819	.	½	43.11	.0	838
.	½	46.49	.1	065	7	5	50.41	.1	[illegible]21
2	10	54.19	.1	398	.	½	58.11	.1	612
.	½	61.49	.1	866	6	6	65.41	.2	213
3	9	69.19	.2	648	.	½	73.11	.3	308
.	½	76.49	.4	269	5	7	80.41	.6	095
4	8	84.19	.10	048	.	½	88.11	.31	[illegible]28

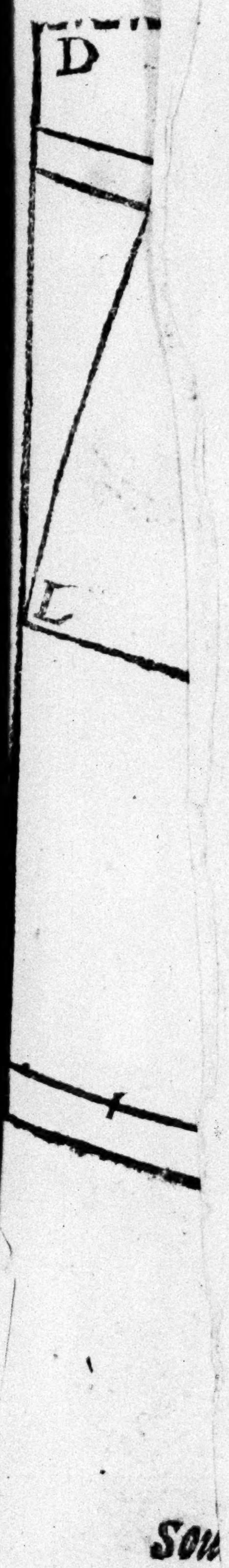
These things prepared, make the Table for the houres; adde unto them their Equinoctiall distances from the Substile, as in the example adjoyning; wherein because 11 of clocke is but 15 d from the Meridian, take 15 d. out of 24 d. 19'. there shall remaine 9 d. 19' for the Equinoctiall distance of the houre from the Substile; then take 24 d. 19' out of 30 d. the distance of 10 of clock, there shall remaine 5 d. 41', for that houres distance from the Substile; the rest of the houre distances are easily had, by continuall addition of 15 d. Vnto these houres distances joyn the naturall tangents as you did in the East and West Dials, which will give you the true distances upon the line LK of the plane of every houre from the Substile: seeing that LFK is a tangent line in respect of the Radius EF, you may also by helpe of the chord set the Equinoctiall distance from the Substile upon each arch HOF: and CEO: and from their centers draw streight lines, to intersect the tangent lines 6 E 3 and LNK: which shall agree precisely with the naturall tangents aforesaid; if there be no error in the worke.

FL the naturall tangent of 6 of clock——	2 213	
FK the naturall tangent of 3 of clock——	2 648	*Logar.*
LK the whole line is——————	4 861	0686.7256
EF the length of the stile proportioned to LK is——————	0 2057	9313.2744:
	Comple-	0

Arithmeticall complement thereof gives the length of the stile.

The Geometricall projection.

To draw this Diall true, consider the Scheme, let ABCD be the Horizontall line, drawne upon the reclining flat, most convenient for the houre lines; which will be alwayes a parallel to the base thereof, representing AZB of the Scheme; upon any part of this line as at B, make an arch of a circle CEO, (equall to 60 d. of the chord) representing AGB the reclining plane in the Scheme; from C unto E reckon the distance of BP in the Scheme betweene the Horizon and Meridian, which giveth the place of the Substile, on the Westside of the center B, when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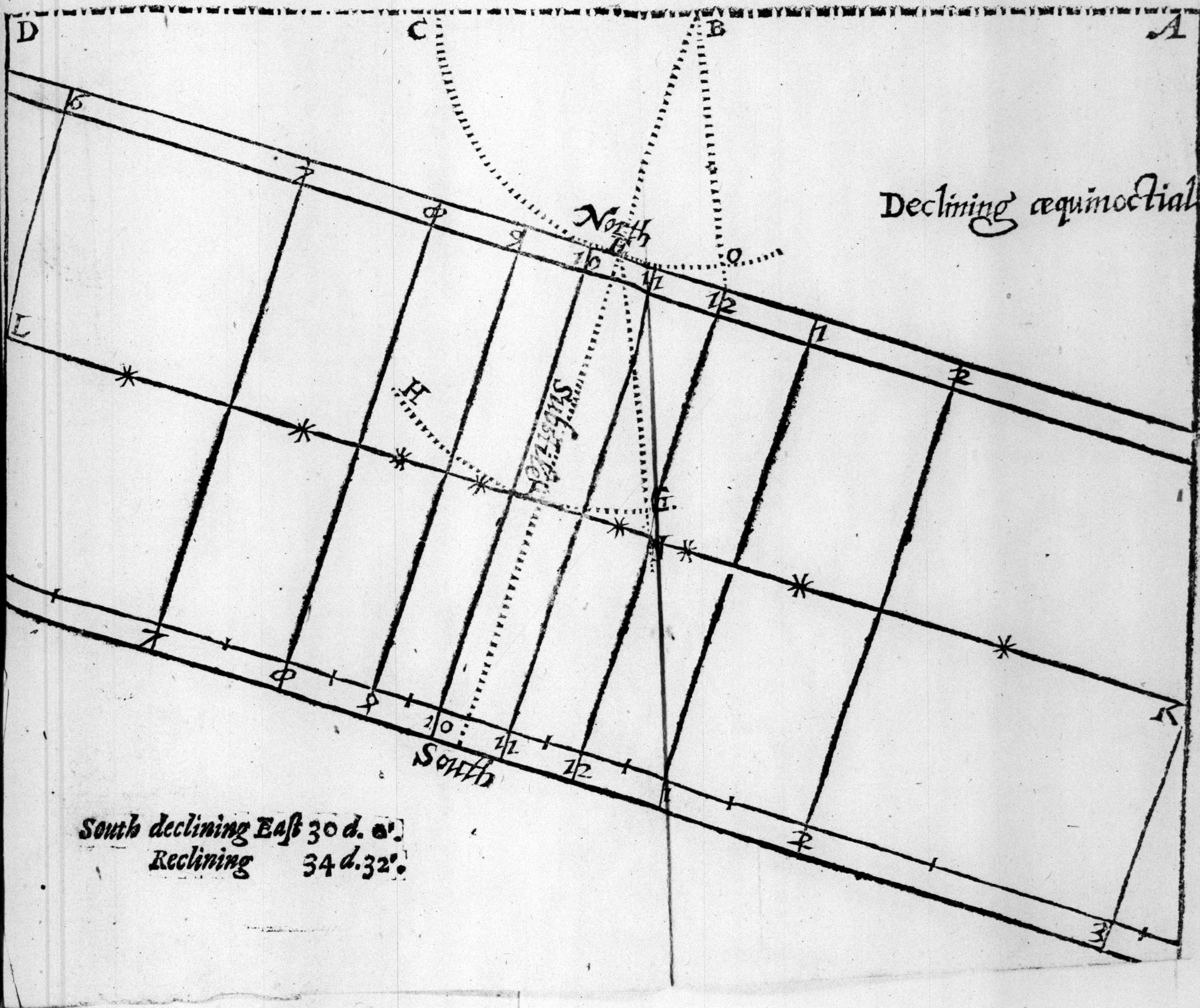
Place this folio 174.



South declining East 30 *d.* 0'.
Reclining 34 *d.* 32'.

when the declination is Easterly; on the East side when Westerly agreeable to the Scheme inverted; thorough the point E draw the line B E F for the Substile line; upon E, or any other part of the Substile where you will make another arch of a circle (with the same chord) F O H: for the Equinoctiall crosse the Substile at right angles, both in E and F: 6 E 3, and L F K shall be two tangent lines to the arches C E O and F O H, drawne with the Semidiameters B E and E F; upon the arch G F H from F to G reckon the angle betweene the Meridians 24 d. 19′: or take the naturall tangent thereof, 0 452 (opening the Sector to the Radius E F) and set it upon the streight line F K from F to N; doe the like upon the other arch, and tangent line E 3: and draw the lines E O N, and B O 12, whose intersections upon the tangent lines shall be in the Meridian of the place: and that Easterly from the Substile when the declination is East, (as in this example) but Westerly when the plane declineth West (because in this Diall the Substile is first given, and the Meridian found from that.) Set of the rest of the tangents from F and E, both wayes by helpe of the Sector, or line divided into 100 parts, as you find them in the Table, *viz.* for 11 H. 0 164 for 1 H. 0 819 for 2 H. 1 392 and so of the rest. Vnto every one of these points draw parallels to the substile, which will crosse the tangent lines at right angles, and so be all the houre lines truly drawne. The stile must either be a streight pin of the length of E F the radius, erected perpendicularly upon the plane in the point F, or else a long square at the same heighth erected ouer the Substile, and so is the Diall finished for use; and further you may note, that by the rules of the 9 or 13 Chapters, you may proportion both the length of the stile, and wideth of the houre lines to the capacitie of the plane, seeing that L F K, is a tangent line to the Radius E F, as you see done by the tangents of F L, and F K, the two extreme houres of the Diall. The Diall being drawne and placed, according to the declination 30 d. Easterly, and the whole plane at E raised to an angle of 55 d. 28′ the complement of the reclination, the shadow of the stile shall give the houres of the day desired.

CHAP.

CHAP. XVI.

To draw the houre lines upon a South reclining plane, declining East or West which passeth betweene the Zenith and the pole.

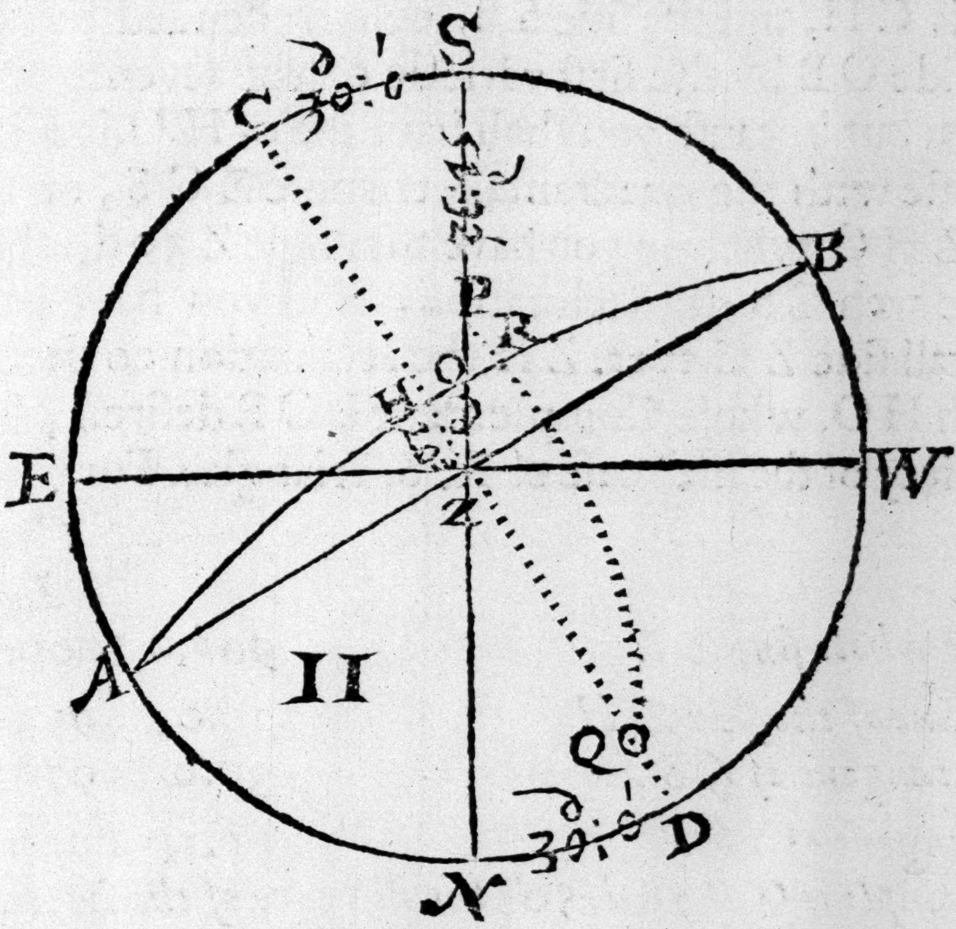
The second Example.

IN this second kinde of declining reclining planes, the south pole is elevated above the p[illegible] as may appeare by this or the greater Scheme of the former Chapter: wherein the circle A H B representing the plane, falleth betweene the Zenith Z, and the North pole P, and therefore hideth that pole from the eye, and forceth you to seeke the elevation of the contrary pole above the plane; which notwithstanding maketh the like and equall angles upon the South side objected to it, as the North pole doth upon the Northside, (as is proved in the Diagram of the 12 Chap.) so that either you may imagine the Scheme to be turned about, and the North and South points changed, and then it will represent the South part of Heaven; or you may calculate the houres as it standeth, remembring to turn the stile upwards or downwards, and change the numbers of the houres, as the nature of the Diall will direct you.

Data	Elevation of the pole P S		51^{d}.32'.
	South	Declining East——S C	30^{d}.0.
		Reclining————Z H	20.0'.

Quæsita	1 distance of Meridian and Horizon O B	78$_{d}$.50'
	2 heighth of the stile————P R	13.[illegible]
	3 distance of substile and Meridian————R O	7.[illegible]
	4 angle betweene the two Meridians—O P R	28.52

The



The Demonstration.

In this and all the like declining reclining Dials, there are foure things to be sought, before you can calculate the houres, the first is the distance of the Meridian from the Horizon upon the plane, which in this particular Scheme is part of the arch of the plane O B; N P S being the meridian of the place, and B the point in the Horizon intersected by the plane.

Secondly, the heighth of the pole or stile above the plane, which is part of the great circle P R Q, passing from the pole of the plane at Q unto the pole of the World at P, and elevated above the plane A H B, the quantitie of P R.

Thirdly, the distance of the substile and meridian upon the the plane, represented by O R, P R Q being the substile or meridian of the plane, and N P S the meridian of the place.

Lastly, the angle betweene those two meridians O P R, all which foure demands, are by the helpe of Logarithmes found out at five easie operations, in manner following.

The Arithmeticall calculation.

In the Rectangular Triangle O S B, you have the right Angle at S, and the acute Angle at B, whose mea-

measure is C H, and the side S B, comprehended by them; to find the side O B by the first varietie of the seventh case of R S Triangles: but because you shall have use of H O, it will be better to deale with the quadrantall triangle Z C S, or the lesser triangle Z H O; wherein you have the angle Z 30 d, whose measure is the arch C S the declination, and you have part of the quadrantall side Z C, *vizt*. Z H, the reclination 20 d: to find the lesser arch H O, whose Complement is O B desired, by the second variety of the fifth case of R. S. Triangles. For

		Logar.
1 *As the whole sine Z C*	90 d.0	10000.00
Is to the sine of the side Z H	20.0	9534.05
So is the tangent of C S	30.0	9761.44
To the tangent of H O	11.10	19295.49

Whose Compl: is O B 78 d. 50', the distance of the Meridian from the Horizon.

2 In the triangle H Z O, you have the angle at Z 30 d. and the side opposite H O 11 d. 10' with the right angle at H; to find the side Z O, which taken out of Z P, leaveth P O by the first varietie of the eighth case of R. S. Triangles. For

		Logar.
As the sine of the angle H Z O	30 d.0'	9698.97
Is to the sine of the side H O	11.10	9287.05
So the sine of Z H O	90.0	10000.00
to the sine of the base O Z	22.47	9588,08

Out of Z P 38 d. 28', take Z O 22 d. 47', there resteth P O 15 d. 41'.

3 In the verticall triangle Z H O, and P R O, because the sines of the Hypotenusas, and perpendiculars are proportionall, you may deal with both together to find P R the heighth of the stile by the 15 of the fourth of *Regiomontanus*, or the second of the 14 of *Finkius*; For

As

			Logar.
As the sine of the hypotenusa Z O	22 d.	47	0412,00, arith. cō.
Is to the sine of the perpendicular Z H	20	0	9534,05
So is the sine of the hypotenusa P O	15	41	9431,88
To the sine of the perpendicular P R	13	49	19377,93

The heighth of the stile desired, (where you may remember the former caution, to auoid substraction, because the Radius is none of the three proportionals given.

4 In the triangle P RO, you have the sides P R, and P O given, and the right angle at R, to find the side O R, by the second variety of the third case of R S Triangles.

			Logar.
As the Cosine of P R	13 d,	49′	9987,25
Is to the sine of P R O	90	0	10000,00
So is the Cosine of P O	15	41	9983,52
To the Cosine of O R	7	30	9996,27

The distance of the substile from the meridian.

5 In the same triangle P RO you have the three sides given, and the right angle at R; to find the angle at P, by either varietie of the 15 and 16 Cases of R.S Triangles. For

			Logar.
As the sine of the side P O	15 d,	41′	9431,88
Is to the sine of the angle P R O	90	0	10000,00
So is the sine of the side R O	7	30	9115,69
To the sine of the angle R P O	28	52	9683,81

Now as in all the former workes the angle P betweene the two Meridians being 28 d. 52′, which is more then one houres distance from the Meridian, and lesse then two, you may conclude that the substile must stand betweene the first and second houre from the Meridian or 12 of clock Westerly, because the declination is Easterly, by that meanes to bring the shadow sooner upon the meridian of the plane, then of the place; wherefore

fore now returne to the generall scheme of the fifteenth Chapter, and let fall a perpendicular betweene 11 and 10 of clocke, but somewhat neere unto 10, as is the prickt line P R upon the circle A H B, by helpe whereof you shall finde the true houre distances as followeth.

Houres and parts from the subst ile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d '		d '	d '
.	½	6.22	8425.51	1.32	1.50
11	1	13.52	8770.38	3.22	1.58
.	½	21.22	8970.36	5.20	2.10
12	12	28.52	9119.29	7.30	2.28
.	½	36.22	9245.02	9.58	2.57
1	11	43.52	9360.74	12.55	3.43
.	½	51.22	9475.25	16.38	4.56
2	10	58.52	9596.87	21.34	7. 3
.	½	66.22	9736.87	28.37	10.55
3	9	73.52	9916.63	39.32	18.1
.	½	81.22	10196.57	57.33	27.43
4	8	88.52	11081.64	85.16	

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d '		d '	d '
10	2	1 8	7674.22	0. 16	1.49
.	½	8 38	8559.29	2. 5	1.52
9	3	16. 8	8839.24	3. 57	2. 1
.	½	23.38	9018.99	5. 58	2.14
8	4	31. 8	9158.99	8. 12	2.36
.	½	38.38	9280.61	10.48	3. 9
7	5	46. 8	9395.11	13.57	4 1
.	½	53.38	9510.84	17.58	5.27
6	6	61. 8	9636.56	23.25	7.59
.	½	68.38	9785.50	31.24	12.49
5	7	76. 8	9985.48	44. 3	20.54
.	½	83.38	10330.35	64.57	

First, therefore make a table for the houres as formerly directed, wherein because the substile fals betweene 10 H. and halfe an houre past, begin with the halfe houre first, and take 22 d. 30′ the Equinoctiall distance of 10 H. and ½ from the Meridian, out of 28 d. 52′, the distance of the substile from the Meridian, there rests 6 d. 22′, the distance thereof from the substile; Likewise take 28 d. 52′, the distance of the substile, out of 30 d. the Equinoctiall distance of 10 of clock from the Meridian, there resteth 1 d. 8′, for the distance of 10 of clock from the substile: Having these two distances on each side of the substile by continuall addition of 7 d. 30′ for ½ houres, and of 15 d. for whole houres, make up the Equinoctiall distances of the rest of the houres, as in the example; Now because 11 H. and 5 H. 12 H. and 6 H. 1 H. and 7 H. 2 and 8 H. 3 and 9 H. and 4 and 10 H. are 90 d. distant in the Equinoctiall each from other, therefore 11 houres being 13. d. 52′ on the one side, 5 H. shall be 76 d. 8′, distant from it on the other side, as by the former addition doth appeare: and by reason that the Equinoctiall distance of one houre is complement to the other 90 d. distant from it, you may at the same work (as hath been often shewed) find the distance of both upon the plane at once; for if you transcribe the Log. Sine of the heighth of the stile into a paper, and adde it to the Logarithm: tangent of 13 d. 52′, you produce a new Log: tangent for the arch of 11 of clock, and adde it to the Logarithm: tangent of 76 d. 8′, the Complement thereof, you produce a new Logarithm: tangent for the arch of five of clock, which will be the same with the operation at large, by the first varietie of the fift case of R. S Triangles as in this Example.

		Logar.
As the sine of P R 11 Scheme 15 Chapter	90 d. 0′	10000.00
Is to the tangent of the angle R P 11	13 52	9392.45
So is the sine of the heighth of the stile P R	13 49	9378.06
To the tangent of the side R 11	3 22	18770.51

And by the same case for R 5 in the triangle R P 5.

As

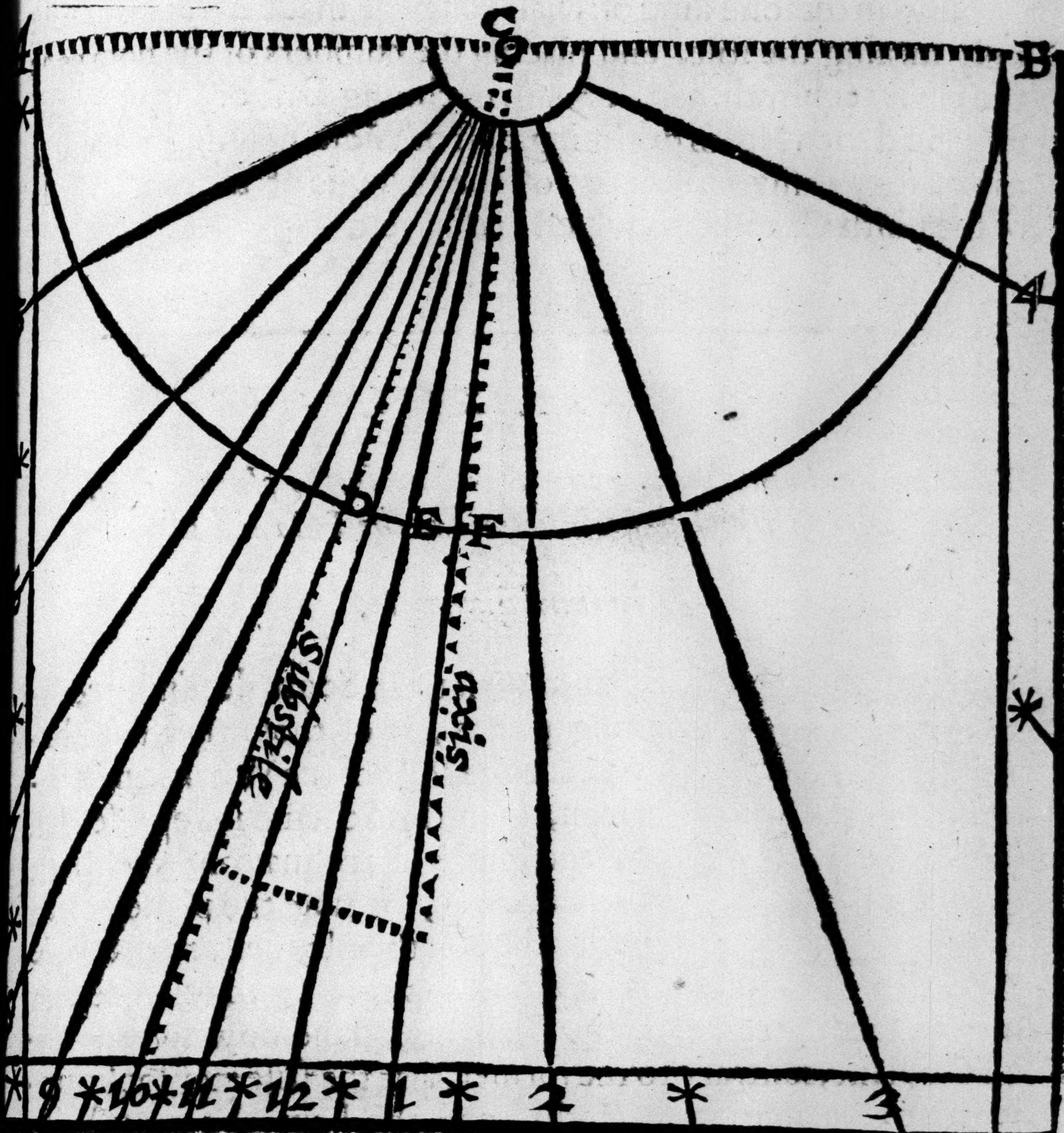
			Logar.
As the sine of P R S	90 d.	0′	10000.00
Is to the tangent of R P S	76	8	10607.55
So is the sine of the side P R	13	49	9378.06
To the tangent of the side R S	44	3	9983.61

And so proceed with all the rest.

The true houre distances upon the plane being thus found, you may easily make the Diall in this manner,

The Geometricall projection.

First draw the horizontall line A C B in the upper part of the plane, because the stile of this Diall must looke downwards to the South pole, and this line in all recliners will be paralell to the base representing A C B of the scheme. Vpon any part of this line, as at C, make the circle A D B (with 60 d. of the chord) representing the reclining circle of the scheme A H B; and because this plane declineth East, the substile and all the morning houres must stand on the West side of the Meridian, as the great scheme of the 15 Chapter doth demonstrate: if you suppose P to be the South pole, and the next side of the reclining flat A H B to the pole, to be the South side thereof, but the particular scheme will better direct you to reckon the distance of the Meridian and horizon in the Diall, from A the West part of the horizontall line, as B standeth from S in the scheme: that so the substile may stand to the Westwards of the Meridian, or the complement of that distance to 180 d. from B, the East part of the Diall, both which will bring the 12 of clocke houre into the due place, agreeable with the scheme, *viz*. A E to B O and E D to R O, therefore by helpe of the chord set of the distance of the Meridian and horizon 78 d. 50′ from A to E, and draw the line C E 12, for the 12 of clock houre, from E reckon 7 d. 30′ the distance of the substile and Meridian Westwards, as R standeth from O in the scheme, and draw the prickt line C D for the substile, from the point D of the substile set of either way, by



South declining East, 30 d. reclining 20 d.

by help of the chorde, the true houre distances of 3 d. 22′ for 11 of clock, and 7 d. 30′ for 12 of clocke, and so of the rest, as they stand in the Table, unto every pricke draw a straight line from the center C, so have you all the houres truly drawne. Last of all set of from D the heighth of the stile D F 13 d. 49′, and draw the line C F for the axis, which erected directly over the substile C D, the Diall is perfected for use, but must be placed in its due position by the declination and reclination thereof.

Now

Now in this one kind of Diall you have made 4 (as foresaid) only turning the stile, and placing the numbers of the houres as the plane requireth, *viz.* a South declining East or West, reclining 20 d. or a North declining East or West inclining as much, as you may easily collect out of the analogie of the foure Dials of the ninth Chapter, to which I refer you.

CHAP. XVII.

To draw the houre lines upon a South reclining plane, declining East or West which passeth betweene the Pole and Horizon.

The third Example.

THe third varietie in South declining reclining planes, is of those that passe betweene the Pole of the World, and Horizon, as in this Scheme is represented by the circle of reclination A F B. In this example, because the plane falleth under the North pole, therfore that pole is elevated above it, from whence you may collect the center of the Diall must stand downwards upon the plane, contrary to the former, that the stile may looke upwards to the pole it respecteth, and the houre lines must also point the same way as in the Scheme alone is manifest.

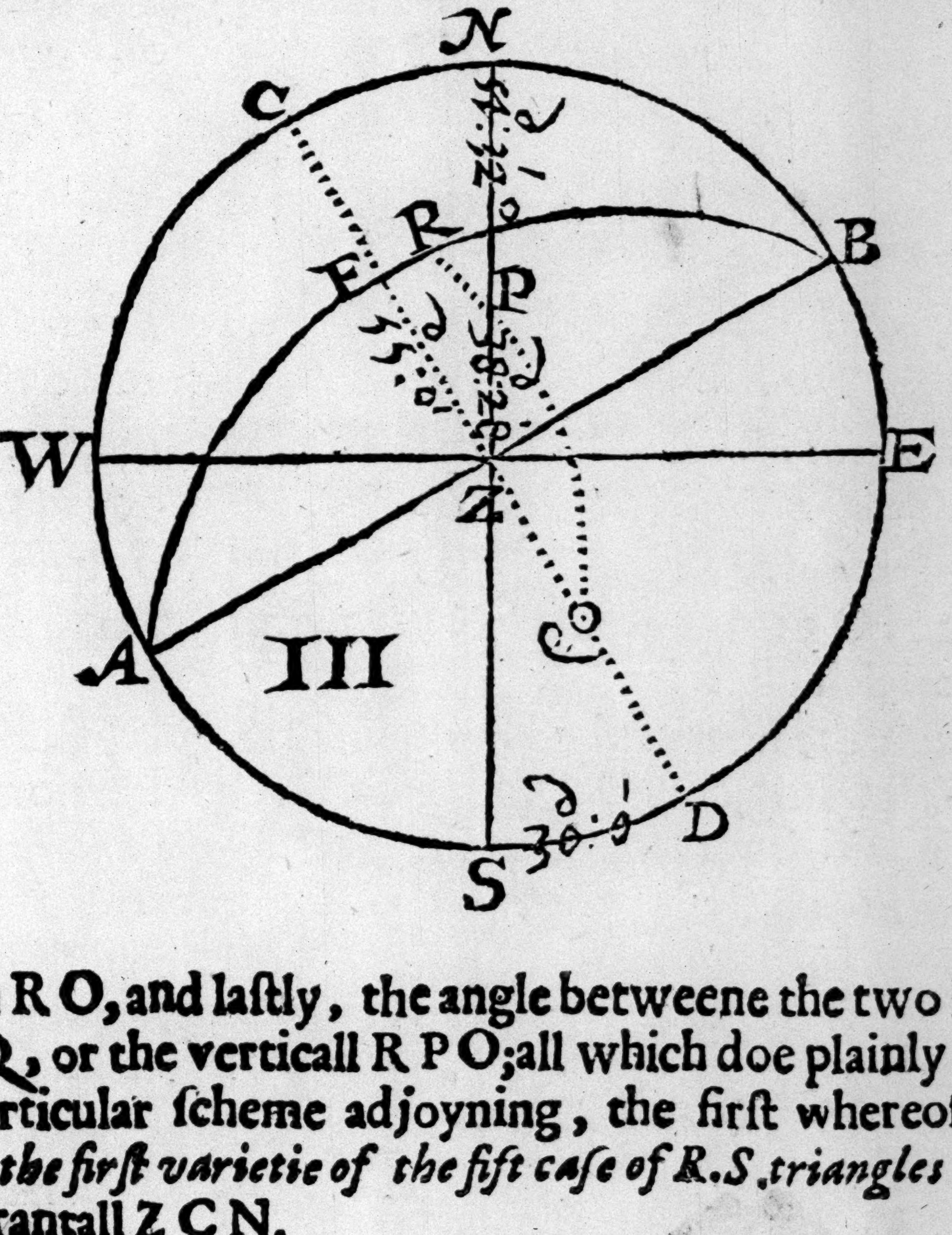
Data	Elevation of the pole P N		51 d.	32′
	South	Declining East S D	30	0
		Reclining Z F	55	0

Quæsita	1 the distance of the Merid. & horizon O B	64 d.	41′
	2 the heighth of the stile PR	19	25
	3 the distance of the substile & Merid. R O	6	2
	4 the angle between the two Merid. R P O	17	38

The

The Demonstration.

Now the same foure things, that you found for the former Diall, must also be sought for this, before you can calculate the houres, *viz.* First, the distance of the Meridian and Horizon upon the plane O B. Secondly, the heighth of the pole or stile above the plane P R. Thirdly, the distance of the substile and



Meridian R O, and lastly, the angle betweene the two Meridians Z P Q, or the verticall R P O; all which doe plainly appeare in the particular scheme adjoyning, the first whereof O B is found *by the first varietie of the fift case of R. S. triangles*: for in the quadrantall Z C N.

The Arithmeticall calculation.

			Logar.
As the whole sine Z C	90ᵈ	0′	10000.00
to the sine of the reclination F Z	55	0	9913.36
is the tangent of the declination C N	30	0	9761.44
To the tangent of F O	25	19	19674.80

O

Whose

Whose complement is O B 64 d. 41′, the distance of th Meridian and Horizon.

2 In the triangle B N O you must seeke the side NO, *by the first of the first case of R.S triangles*, or in the quadrantall B C F, *by the first of the fift case*. For

			Logar.
As the sine of B N O	90 d.	0′	10000.00
Is to the sine of BO	64	41	9956.15
So is the cosine of the reclination NBO	35	0	9758.59
To the sine of N O	31	14	✗9714,74

Or againe,

			Logar.
As the whole sine B C	90 d.	0′	10000.00
Is to the tangent of F C	35	0	9845.23
So is the sine of B N	60	0	9937.53
To the tangent of N O	31	14	✗9782.76

Take N O 31 d. 14′ out of N P 51 d. 32′, there resteth P O 20 d. 18′

3 Because the sines of the Hipotenusas and perpendiculars of the verticall triangles R O P and N O B are proportionall, you may deale with both at once to find R P, *by the 15 of the fourth of Regiomontanus, or by the second of the fourteenth of Finkius*. For

			Logar.
As the sine of the Hypotenusa B O	64 d	41′	0043.84 A.co
Is to the sine of the Hypotenusa P O	20	18	9540,25
So is the sine of the perpendicular N B	60	0	9937.53
To the sine of the perpendicular R P	19	25	✗9521.62

Therefore R P 19 d. 25′ is the heighth of the pole or stile above the plane.

4 In the triangle R P O seeke the side R O, *by the first of the third case of R.S. triangles*. For

As

			Logar.
As the cosine of R P	19 *d.*	25'	9974.57
Is to the sine of P R O	90	0	10000.00
So is the cosine of P O	20	18	9972.15
To the cosine of R O	6	2	9997.58

Or if you will by the same verticall triangles, and second axiome of *Pitiscus*.

			Logar.
As the tang. of the perpẽdicular NB	60 *d.*	0'	9761.43. *Ar. cõpl.*
Is to the sine of the base N O	31	14	9714.77
So is the tang. of the perpẽdicular RP	19	25	9547.14
To the sine of the base R O	6	2	&9023.34

The distance of the substile from the Meridian.

5 Lastly, in the same triangle R P O seeke the angle at P, *by the first of the fift case of R. S. triangles.* For

			Logar.
As the sine of the side P O	20 *d.*	18'	9540.25
Is to the sine of the angle P R O	90	0	10000.00
So is the sine of the side R O	6	2	9021.63
To the sine of the angle R P O	17	38	9481.38

Therefore 17 d. 38' is the angle R P O betweene the two Meridians equall to Z P Q, because they are verticals.

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
11	1	2.38	8184.30	0.53	2.31
.	½	10. 8	8773.81	3.24	2.38
12	12	17.38	9023.85	6. 2	2.50
.	½	25. 8	9192.92	8.52	3. 9
1	11	32.38	9328.03	12. 1	3.38
.	½	40. 8	9447.48	15.39	4.22
2	10	47.38	9561.59	20. 1	5.29
.	½	55. 8	9678.54	25.30	7.12
3	9	62.38	9807.61	32.42	9.55
.	½	70. 8	9963.70	42.37	13.58
4	8	77.38	10180.67	56.35	19. 3
.	½	85. 8	10591.46	75.38	

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
.	½	4 52	8451.77	1. 37	2.33
10	2	12.22	8862.56	4. 10	2.41
.	½	19.52	9079.53	6. 51	2.55
9	3	27.22	9235.62	9. 46	3.16
.	½	34.52	9364.69	13. 2	3.50
8	4	42.22	9481.64	16.52	4.39
.	½	49.52	9595.79	21.31	5.55
7	5	57.22	9715.20	27.26	7.53
.	½	64.52	9850.31	35.19	10.58
6	6	72.22	10019.38	46.17	15.27
.	½	79.52	10269.43	61.44	20.23
5	7	87.22	10858.93	82. 7	

The

These things being found, first make the Table for the houres as is heretofore directed, considering, that because the angle betweene the Meridians is greater then one houres Equinoctiall distance from 12, and lesse then two, therefore the substile (from whence the other houres distances are to be set) must fall between 11 and 10 of clocke (for the reasons heretofore alleaged) *viz.* 2 d. 38′ from 11 houres, as by substraction of 15 d. the Equinoctiall distance thereof out of 17 d. 38′, and 4 d. 52′ from 10 houres ½, as by substraction of 17 d. 38′, out of 22 d. 30′, the Equinoctiall distance of 10 ho. ½ doth appeare, wherefore begin the table at 11 of clocke, and end it with 10 ½: unto 2 d. 38′, the Equinoctiall distance of 11 houres from the substile, adde 7 d. 30′. so oft as you can under 90 d. and unto 4 d. 52′ for 10 ho: ½ doe the like, so shall you haue the Equinoctiall distances of all the other houres and halfes, the Logarithmeticall tangents whereof being continually added to the Log. sine of 19 d. 25′, the heighth of the stile P R (first transcribed into a paper) shall give you new Logarithmeticall tangents, whose arches are the true houre distances upon the plane, represented by the circle A E R B, for *by the first of the fift case of R. S. Triangles*, the two triangles 11 P R, and 5 P R of the greater Scheme of the 15 Chapter, comprehending 90 d. in the Æquator may be resolved together.

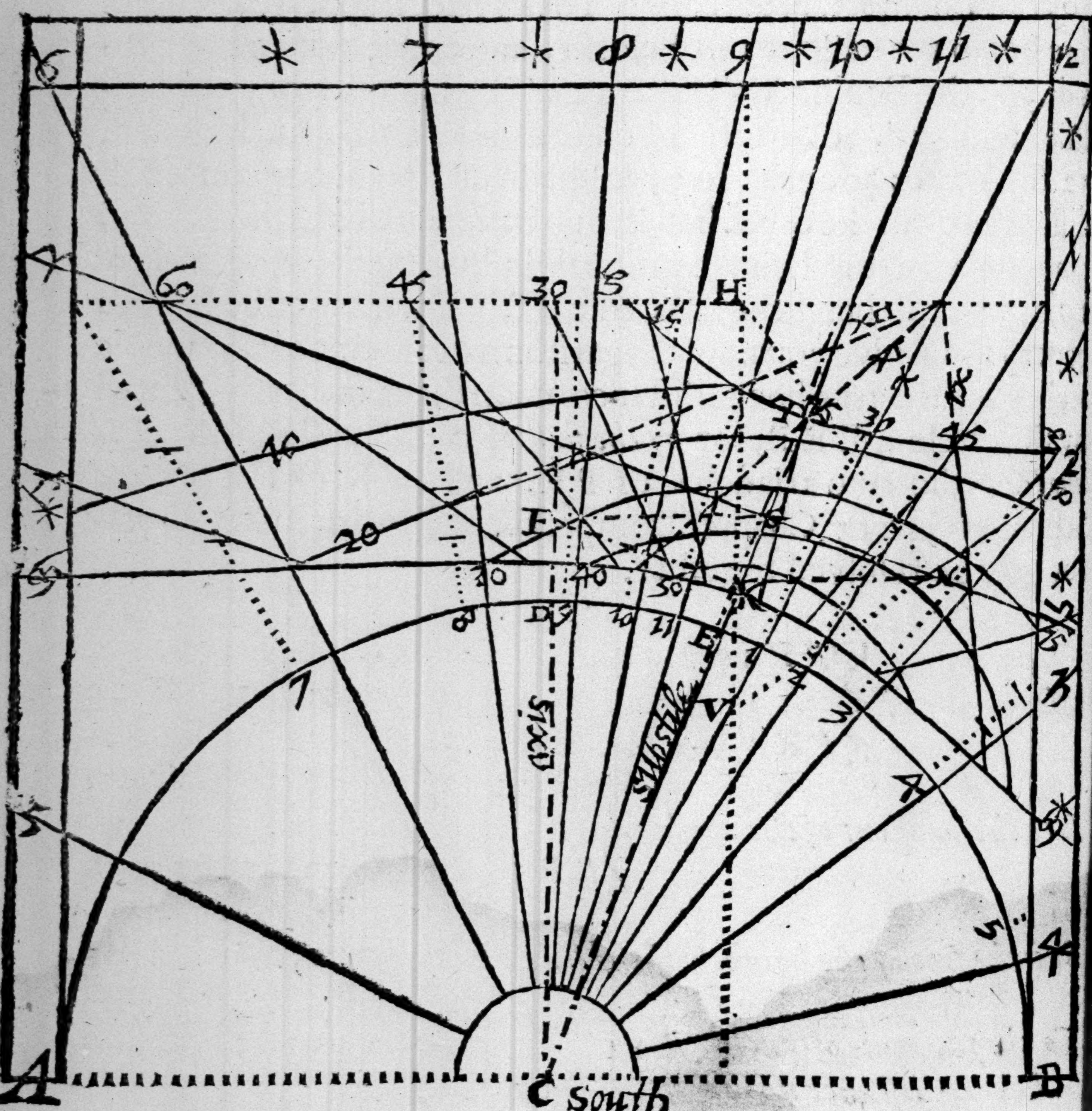
		d.	′	*Logar.*
As the sine of	*P R* 11 or *P R* 5	90 *d.*	0′	10000.00
Is to the tangent of the angle	*R P* 11	2	38	8662.69
	or			
	R P 5	87	22	11337.31
So is the sine of the heighth of the stile P R		19	25	9521.71
To the tangents of each houres distance upon the plane	*R* 11	0	53	18184.40
	or			
	R 5	82	7	18859.02

Wherefore (as the Table sheweth) the first houre R 11 is distant

stant from the substile o d. 5 3′, and R 5 six houres distant from eleven is 82 d. 7′, So is R 12. 6 d. 2′. R 10. 4 d. 10′, R 1. 12 d. 1′, R 9. 9 d. 46′, and so of the rest.

The Geometricall projection.

The Table being prepared, and the houres distances calculated, draw the Horizontall line A C B, paralell to the base re-



South declining East	30 *d.*
Reclining	55 *d.*

pre-

presenting A Z B of the Scheme, towards the lower part of the plane, because the center must stand downwards, and the stile and houres point upwards to the pole, as appeares by the very inspection of the Scheme. In any part of this Horizontall line, as at C, place the center, and with the length of 60 degrees of the chord, draw the arch A D E B, representing the reclining circle A F O B of the Scheme. In this arch place the Meridian, substile, and houres, as they lie in the Scheme, and you cannot doe amisse, *viz.* from B the Easter part of the Horizontall line of the Diall, set off by helpe of the chorde unto 1, B O of the Scheme 64 d. 41′, the distance of the Meridian from the Horizon, and draw C V 12, for the 12 of clocke houre from the line of 12 unto E reckon O R of the Scheme 6 d. 2′ the distance of the substile from the Meridian, which set of Westwards, agreeable to the Scheme, because the declination is Eastwards, and draw the prickt line C E for the substile, from the point E both wayes set of by helpe of the chord, the houre distances of 10. 9. 8. 7. 6. 5. to the Westward therof, & 11. 12. 1. 2. 3. 4. to the Eastward for the rest of the houres (as you may see them lie in the greater Scheme of the 15 Chapter) and to each pricke draw straight lines from the center, so is the Diall finished for use. Last of all, set of the heighth of the stile P R 19 d. 25′ from E to D, and draw the line C D representing the axis, which being erected perpendicularly over the substile line C E, the base A C B declining 30 d. Eastwards, and the whole plane at 6. 12 raised to an angle of 35 d. above the Horizon, will shadow the true houre lines upon the plane, and so you have done with the three varieties of South declining reclining Dials. Wherein also note that having made this one Diall (or any of the like) you have at once made foure, changing but the position of the Dials, and altering the numbers of the houres, as the plane doth require, for first this answereth to the opposite the North declining 30 d. West, and inclining to the Horizon the Complement of the reclination 35 d. also the South declining 30 d. West reclining 55 d. or to his opposite North declining East 30 d. and inclining to the Horizon 35 d. which because they are by the example of the ninth Chapter easily deduced one out of the other,

ſhall not need to ſpend more time about them, yet this one thing more may be obſerved, that for variety ſake, and ſome eaſe alſo in the Worke, if you take O P the arch of the Meridian betweene the pole and the plane, in the laſt Diagram 20 d. 18′ for the latitude, and the angle N O B, or P O R betweene the Meridian and the plane 73 d. 20′ for the reclination, you may reduce this declining reclining plane, or any other after the ſame manner, into an Eaſt or Weſt reclining plane, unto which Diall being made, it ſhall give the ſame houre lines that the former hath done, as may eaſily be tried by the rules of the 12 Chapter, yeelding the ſame elevation of the ſtile 19 d. 25′. the ſame diſtance of the ſubſtile and Meridian 6 d. 2′, and the ſame angle between the Meridians 17 d. 38′, which by the ſeverall ſchemes will at the firſt ſight plainly appeare.

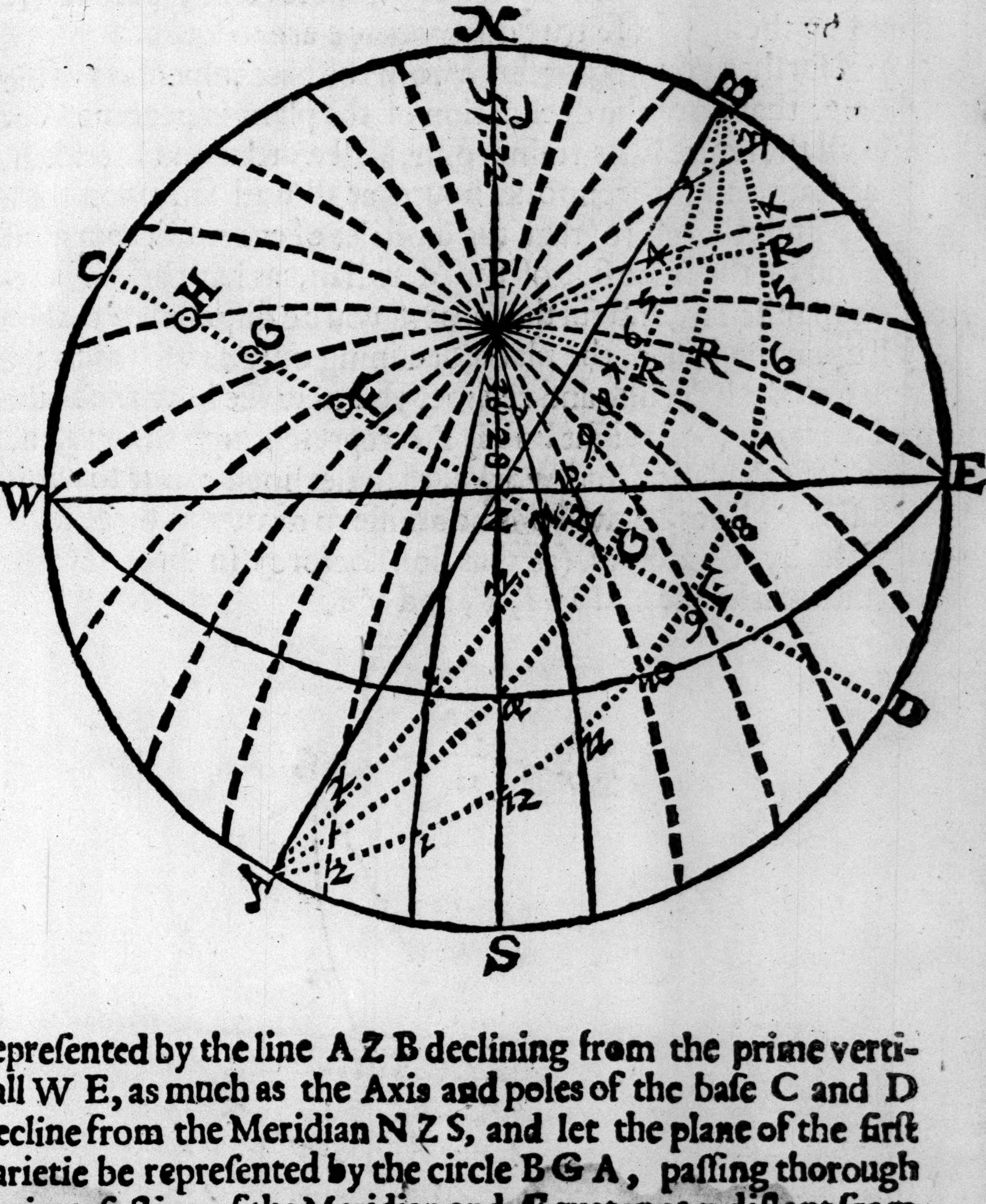
CHAP. XVIII.

To draw the houre lines upon the polar plane declining Eaſt or Weſt, being the firſt variety of North declining reclining planes.

AS in the ſouth reclining decliners there are three varieties, ſo are there in the North as many: for either the plane reclining doth paſſe by the interſection of the Meridian & Æquator, and then it is called a declining polar, which hath the ſubſtile alwayes perpendicular to the Meridian, or elſe it paſſeth above or under the interſection of the Meridian and Æquator, which ſomewhat differeth from the former. I will therefore firſt ſhew how they lie in the Scheme, and then proceed to the particular making of the Dials proper to each of them.

The Demonſtration.

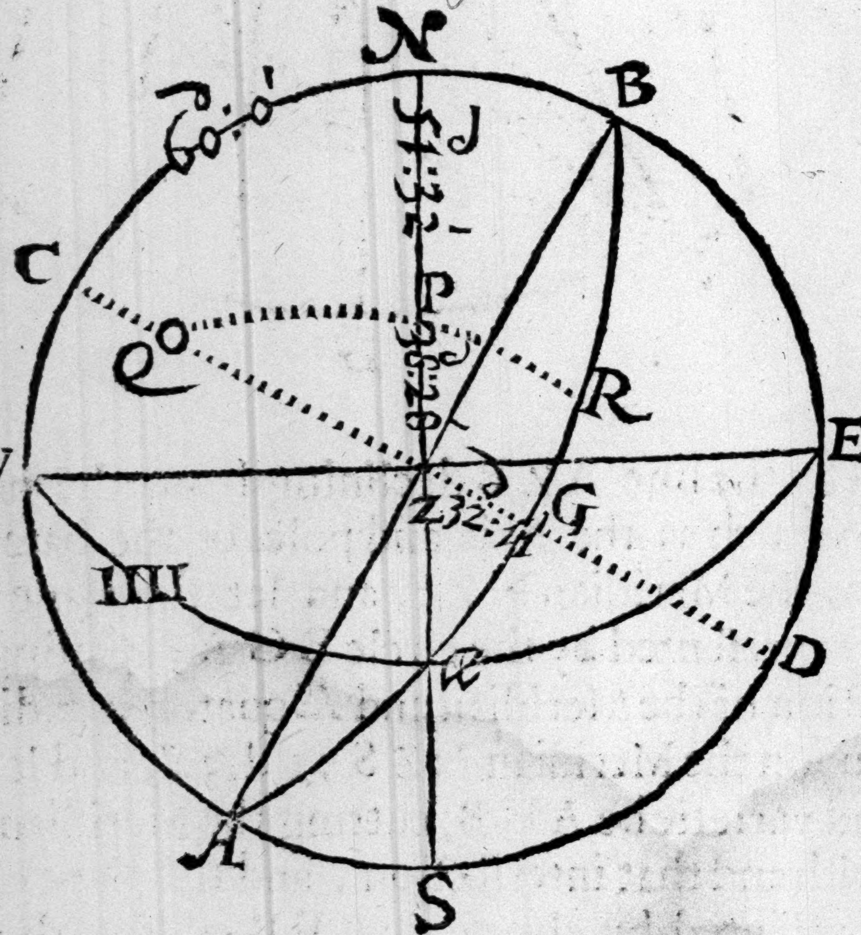
Let the North declining baſe in the Scheme adjoyning be repre-



represented by the line A Z B declining from the prime verticall W E, as much as the Axis and poles of the base C and D decline from the Meridian N Z S, and let the plane of the first varietie be represented by the circle B G A, passing thorough the intersection of the Meridian and Æquator at æ, distant from the Zenith upon the Meridian N Z S 51 d. 32′, and let the plane of the second varietie be A H B, cutting the Meridian betweene z æ the Zenith and that intersection, and the plane of the third varietie represented by the circle A F B cutting the Meridian betweene S æ the Horizon and that intersection; Now as the houre lines from P the pole of the World cut each of those reclining

clining circles, so will they fall upon the severall planes represented by them, whose true distances we are to seeke.

And further you may observe from the bare inspection of the Scheme, that now the declination of the plane is become Westerly, all the houre lines runne to the Eastward of the Meridian, so that scarce any fourenoone houres at all will fall upon these planes, and therefore that the substiles of every of them must also stand on the same side of the Meridian, as hath beene heretofore manifested, and further that if you be disposed to make a Diall upon the base of the plane, declining only, as well as to the plane that doth decline and recline, you may see how the houre lines fall upon the streight line B Z A representing the same, and frame the calculation and worke, as in decliners: But to avoid confusion of lines, it will not be amisse to draw the three severall Cases by themselves (as was done before) in three severall Schemes marked with IIII, V, and VI.



Data

Data
- Elevation of the pole P N 51 d. 32′.
- North
  - Declining Weſt N C 60 d. 0.
  - Reclining Z G 32 11′.

Quæſita
- 1 diſtance of Meridian and Horizon A æ 47 d. 18′
- 2 heighth of the Pole or Stile P R 42. 52

The firſt Scheme repreſenteth the declining reclining plane, paſſing by the interſection of the Meridian and Æquator, Z G being the reclination 32 d. 11′, and Z æ the diſtance of the Equinoctiall from the Zenith 51 d. 32′. The ſecond ſort cutteth the Meridian at O betweene the Zenith and Æquator, as doth the circle B H A repreſenting the plane in the Diagram of the next Chapter marked with V. The third ſort cutteth the Meridian alſo at O betweene the Horizon and Æquator, as doth the circle B F A repreſenting the plane in the Diagram of the 20 Chapter marked with VI.

From C in each Diagram upon the line C Z D, repreſenting the Azimuth, croſſing the planes at right angles, ſet of the quantitie of each ſeverall reclination, ſo ſhall you have points at Q, repreſenting the poles of each reclining plane, ſo much raiſed above the Horizon N E S W, as the reclining planes are falne from the Zenith Z, from which points at Q you muſt draw the arches of great circles (whoſe centers or poles will be alwayes in the periphery of the planes) paſſing thorough the pole of the World P, and croſſing the reclining planes at right angles in R, and theſe repreſent the Subſtiles, or Meridians of the planes, as the lines N P, Z S doe the Meridians of the place, and PR in each of them giveth the heighth of the pole or ſtile above the plane, and R æ, R O, the diſtance of the ſubſtile and Meridian, A æ A O the diſtance between the Meridian and Horizon, and æ PR, O P R the angle betweene the two Meridians, all which foure things muſt be found as in the former declining reclining they were, before you can proceed to calculate the houre diſtances or frame your Diall.

And

And here also as in the 14 Chapter, there may be a reclination found to any declination given, and contrary, by which to fit the plane howsoever declining, to passe thorough the intersection of the Meridian and Æquator, whose stile is alwayes perpendicular to the Meridian, therefore in the triangle Z G æ, or rather in the quadrantall A D G, let S D the declination be given, and S æ the complement of the elevation, or heighth of the Equinoctiall above the Horizon, to find D G, whose complement is G Z the reclination desired, *by the second of the sixt case of R. S. Triangles.* For

			Logar.
As the sine of A S the complement of the declination	30d	0′	9698.97
Is to the tangent of S æ, the comple. of the eleva.	38	28	9900.09
So is the whole sine A D	90	0.	10000.00
To the tangent of D G	57	49	10201.12

Therefore G Z the complement thereof 32 d. 11′. the reclination desired, the contrary part is performed by the converse of this: for

			Logar.
As the tangent of G D	57d.	49′	10201.12
Is to the tangent of æ S	38	28	9900.09
So is the whole sine D A	90	0	10000.00
To the sine of S A	30	0	9698.97

Whose complement S D is 60 d. the declination desired.

The Arithmeticall Calculation.

Now therefore for the declining polar, that is, whose reclining plane passeth by the intersection of the Equinoctiall and Meridian (as in the first Diagram) you must seeke A æ, the distance of the Meridian N Z S from A the point of the Horizon, by which the reclining plane passeth, which may be found by three severall Triangles, either A S æ, or the verticall Z G æ, or the quadrantall S Z D.

In the first you have A S 30 d. 0′, and S æ 36 d. 28′, and the right

right angle at S; to find the base A æ, *by the ninth Case of R.S. Triangles.*

In the second you have the base Z æ 51 d. 32′ and Z G 32 d. 11′, and the right angle at G; to find the side G æ, *by the second of the third Case of R.S. Triangles.*

Or lastly in the quadrantall S Z D you have the angle Z 60 d. whose measure is D S the declination, and you have Z G 32 d. 11′ the reclination, and the quadrantall Z D 90 d. to find G æ, whose Complement is A æ *by the first of the fift case of R.S. Triangles, the thing desired.* For

			Logar.
1 *As the whole sine Z D*	90 d.	0′.	10000.00
Is to the tangent of D S	60	0	10238.56
So is the sine of the side Z G	32	11	9726.42
To the tangent of G æ	42	42	9964.98

Whose Complement 47 d. 18′. is A æ the distance of the Meridian from the Horizon.

2 In the quadrantall æ R P, you must find R P, which is the heighth of the pole above the plane, *by the first of the sixteenth Case of R.S. Triangles.* For

			Logar.
As the sine of æ G	42 d.	42′	9831.33
Is to the whole sine æ R	90	0	10000.00
So is the tangent of G Z	32	11	9798.87
To the tangent of R P	42	52	9967.54

Or againe in the same triangle, *by the first of the fifteenth case.*

			Logar.
As the sine of æ Z	51 d.	32′.	9893.74
Is to the whole sine æ P	90	0	10000.00
So is the sine of Z G	32	11	9726.42
To the sine of P R	42	52	9832.68

3 Because in all decliners (whose planes passe by the inter-

lection

ſection of the Meridian and Equinoctiall) the ſubſtile is perpendicular to the Meridian, therefore you need not ſeeke æ R the diſtance betweene the Subſtile and Meridian, which is alwayes 90 d. falling upon the 6 of clock houre.

4. Laſtly, the arch æ R which is the diſtance of the ſubſtile from the Meridian being 90 d. the angle at P oppoſite thereto muſt be alſo 90 d, from whence it followeth, that every two houres equidiſtant from the 6 of clocke houre in Equinoctiall degrees, ſhall alſo have the like diſtance of degrees in their arches upon the plane, and ſo one halfe of the Diall calculated ſerves for all, as you may ſee in the Table adjoyning.

Houres and parts from the ſubſtile.		Equinoctiall diſtances.	Logarithmes of tangents.	The houre arches on the plane.	Differ.
		d ′		d ′	d ′
6	6	0. 0	*Subſtile.*		
·	½	7.30	8952.12	5. 7	5. 13
5	7	15. 0	9260.74	10. 20	5. 24
·	½	22.30	9449.91	15.44	5. 43
4	8	30. 0	9594.14	21. 27	
·	½	37.30	9717.67	27. 34	6. 7
					6. 40

Houres and parts from the ſubſtile.		Equinoctiall diſtances.	Logarithmes of tangents.	The houre arches on the plane.	Differ.
		d ′		d ′	d ′
3	9	45. 0	9832.69	34. 14	7 20
·	½	52.30	9947.71	41. 34	8 7
2	10	60. 0	10071.25	49. 41	
·	½	67.30	10215.46	58. 40	8 59
1	11	75. 0	10404.64	68. 30	9 50
·	½	82.30	10713.26	79. 3	10.33
12	12	90. 0		90. 0	10.57

Wherein the Substile is supposed to stand upon the 6 of clock houre, being 90 d. distant from 12, therefore place all the rest of the houres, as they are equidistant from 6 together, *viz.* 5 H. and 7. H. 4 H. and 8 H. 3 H. and 9 H. &c. and set unto them like Equinoctiall distances; unto the Logarithmeticall tangents whereof adding the Logarithmeticall sine of the heighth of the pole or stile PR above the plane which is 42 d. 52′ Logar. 9832. 68 (first transcribed into a loose paper) you produce new Log: tangents, *by the first of the fift Case of R. S. triangles*: whose arches are to be set of by helpe of the chorde both wayes from the Substile as hath been often shewed, for

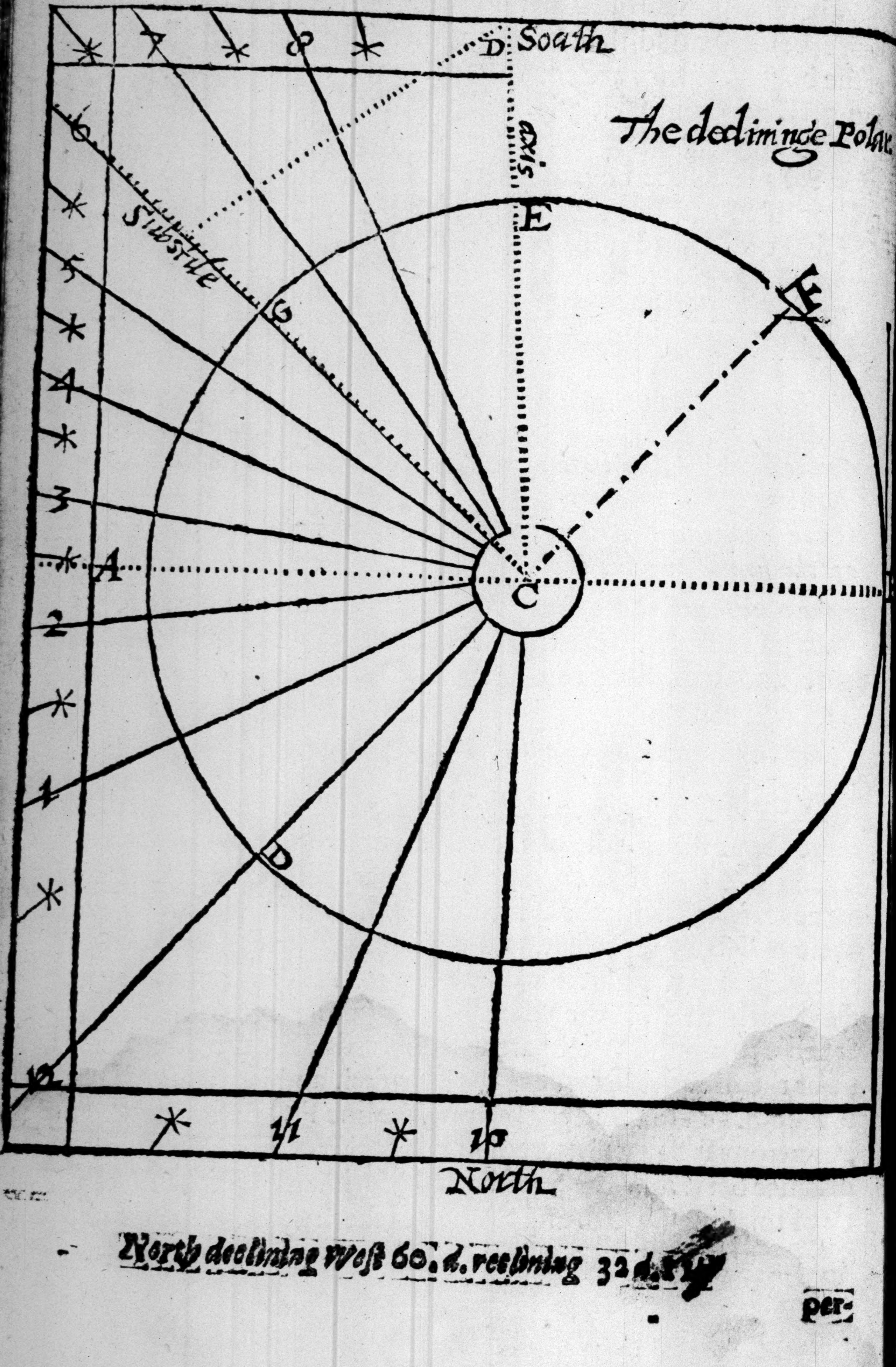
			Logar.
As the sine of R P S in the greater Scheme of this Chapter	90 d.	0′	10000.00
Is to the tangent of R P 5	15	0	9428.05
So is the sine of the side P R	42	52	9832.70
To the tangent of R 5	10	20	X9260.75

Which 10 d. 20′. is the true distance of the fifth and seventh houre, and so of all the rest.

The Geometricall projection.

The Table being prepared, draw the Horizontall line A C B neere about the middle of the plane paralell to the base representing A Z B of the Scheme, in any part thereof, as at C make the center, and with the widest of 60 d. of the chord draw the circle A D B F, representing the reclining plane A G B of the Scheme, from the East side of the Horizon at A downwards for the North part of the Meridian, or (more agreeable to the Scheme) from the West part at B upwards, for the South part set of the distance betweene the Meridian and Horizon A D or B F 47 d. 18′, to those pricks draw the line F C D, for the houre of 12 from F Eastwards, because the declination is West, set the distance betweene the Substile and Meridian, which in all Dials of this kind is 90 d. and therefore falleth upon the houre of 6

per-



North declining West 60. d. reclining 32 d.

perpendicular to the Meridian, & agreeable to the Scheme, in the things desired, *viz.* B F to A æ, F G to æ R, & C F to Z æ, the South part of the Meridian, falling betweene the West part of the Horizon and Substile. Now at the distance of 90 d. draw the line C G 6 for the houre of 6 and Substile, set of from G each wayes (by helpe of the chorde) upon the circle E G A D the houre distances, as you find them in the Table, *viz.* for the houres of 5 and 7, 10 d. 20′. for 4 and 8, 21 d. 27′, and so of the rest (but past 8 you need adde none) so shall you have prickes, unto which streight lines being drawne from the Center, the true houre lines are given. Lastly, from G either way set of the heighth of the stile G E 42 d. 52′, and draw the line C E for the Axis of the World, which being erected perpendicularly over the Substile C G 6, the Diall is prepared for use, and must be rectified by the declination and reclination proper to the same.

CHAP. XIX.

To draw the houre lines upon a North reclining plane, declining East or West, which cutteth the Meridian betwixt the Zenith and Equinoctiall.

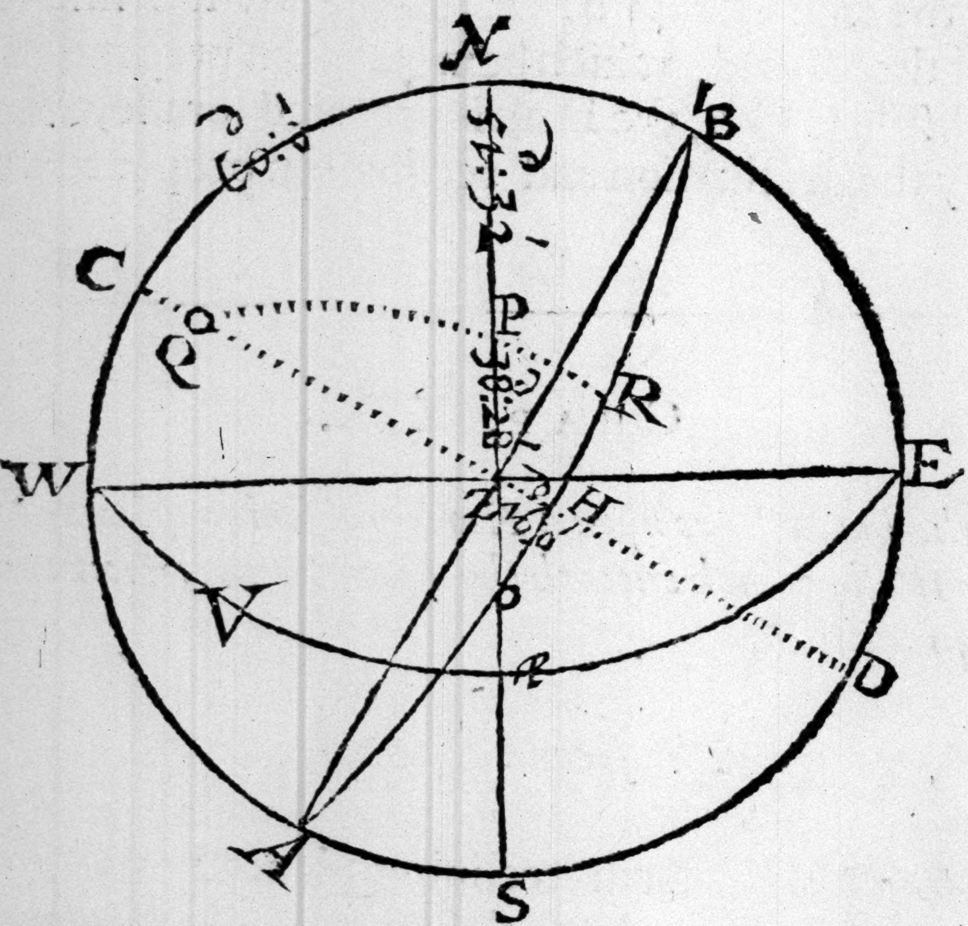
The second Example.

ALL North reclining planes howsoever declining, have the North Pole elevated above them, and therefore the center of the Diall must be so placed upon the plane, that the stile may looke upwards to the Pole, neither can it be expected that the plane being elevated above the Horizon Southward, should at all times of the yeare be enlightned by the Sunne, except it recline so farre from the Zenith as to intersect the Merdian betweene the Tropique of ♑ and Horizon, this plane therefore reclining but 16 d. from the Zenith, and declining 60 d. cannot shew many houres, when

the ☉ is in his greatest Northerne declination, partly by reason of the heighth of the plane above the Horizon, and partly by reason of the great declination thereof, hiding the ☉ beames from all the Morning houres, which may therefore be left out as uselesse.

The Demonstration.

In this second varietie, the plane represented by the Circle B H A cutteth the Meridian at O betweene the Zenith and Æquator, Z H being the reclination 16 d. and Z æ the distance of the Æquator from the Zenith 51 d. 32′. as aforesaid.



Data	Elevation of the pole P N			51 d.	32′.
	North	Declining West	N C	60	0
		Reclining	Z H	16	0

Quæsita	1 the distance of the Merid. & horizon A O	64 d.	29′
	2 the heighth of the stile P R	30	59
	3 the distance of the substile & Merid. O R	64	26
	4 the angle between the two Merid, O P R	76	10

As

As in the former so in this Diall the same foure things are againe to be found before you can calculate the houre distances thereof. The first is A O in the Scheme adjoyning, which is the distance of the Meridian from the Horizon. The second is P R the elevation of the stile or pole above the plane A O R B, the third is O R the distance of the Substile or Meridian of the plane P R from the Meridian of the place N P S. And lastly, the angle O P R betweene the two Meridians aforesaid.

The Arithmeticall calculation.

You may find the distance A O betweene the Meridian and Horizon by three severall triangles, as in the former, but because you may use the same worke in all three varieties, therefore in the quadrantall Z S D you have Z H the reclination given 16 d. 0', and Z D the radius 90 d. and D S equall to C N the declination 60 d. to find H O, whose complement is A O desired, *by the second of the fift Case of R.S. Triangles.* For

			Logar.
1 *As the whole sine Z D*	90 *d.*	0'	10000.00
Is to the sine of the reclination Z H	16	0	9440.34
So is the tangent of the declination D S	60	0	10238.56
To the tangent of H O	25	31	9678.90

Whose complement A O 64 d. 29'. is the distance of the Meridian and Horizon.

2 In the same triangle you may first find out Z O *by the second of the eighth Case of R.S. Triangles.* For

			Logar.
As the sine of the declination D S	60 *d.*	0'	9937.53
Is to the whole sine S Z	90	0	10000.00
So is the sine of the side H O	25	31	9634.25
To the sine of the side Z O	29	50	9696.72

Vnto Z O 29 d. 50'. adde P Z 38 d. 28'. so have you the whole side P O 68 d. 18'.

3 In the triangles O Z H and O P R you may find out P R *by the* 15. *of the fourth of* Regiomontanus, *or the second of the fourth of Finkius*, because the sines of the Hypotenusas and perpendiculars are evermore proportionall each to other. For

		Logar.
As the sine of the hypotenusa O Z	29 d. 50'	0303.22. *Ar. compl.*
Is to the sine of the perpendicu. Z H	16.	0. 9440.34.
So is the sine of the hypotenusa O P	68.	18. 9968.07.
To the sine of the perpendicu. P R	30.	59. X9711.63.

Or if you will in the verticall Triangles A O S and P O R by the same axiomes.

			Logar.
As the sine of O A	64 *d.*	29'	0044.58. *ar. cõ*
Is to the sine of S A	30	0	9698.97
So is the sine of O R	68	18	9968.07
To the sine of P R	30	59	X9711.62

Which 30 d. 59'. is the heighth of the stile or pole above the plane.

4 In the same triangles, you may finde R O by the second Axiome of the fourth of *Pitiscus*, because the sines of the bases and tangents of the perpendiculars are likewise proportionall each to other.

			Logar.
As the tang. of the perpendicular Z H	16 d.	0'.	10542.51. *ar. cõ.*
Is to the sine of the base H O	25	31	9634.25.
So is the tangent of the perpendicu. P R	30	59	9778.49.
To the sine of the base R O	64	26	X9955.25.

Or in the same verticall triangles.

As

			Logar.
As the tangent of S A	30 *d.*	0′.	10238.55
Is to the sine of S O	60	10	9938.26
So is the tangent of P R	30	59	9778.48
To the sine of R O	64	26	29955.29

Which 64 d. 26′. is the distance of the Substile from the Meridian N Z S.

5. Lastly, in the same triangle you may find the angle P, *by the second of the* 14, 15, *or* 16 *cases of R. S. Triangles.* For

			Logar.
As the sine of P R	30 *d.*	59′	9711.63
Is to the sine of P R O	90	0	10000.00
So is the tangent of R O	64	26	10320.20
To the tangent of R P O	76	10	10608.57

Which 76 d. 10′. is the angle O P R betweene the two Meridians, by helpe whereof wee proceed to calculate the houre distances as followeth.

Now then you may conclude (as in the former) because the angle betweene the two Meridians is 76 d. 10′. and that 75 d. is 5 houres distant from the Meridian, the substile from whence you set all the true houre distances must fall betweene 7 and 6 of clocke, reckoned from the South, which in this example is 12 at midnight, and that of the afternoon houres, because the plane declineth so farre Westerly, and is elevated so high above the Horizon, that the Sunne is on the inclining or backe side of the plane all the forenoone; begin therefore the Table at 7 of clock, and end it at 6 ½, as in the example.

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	The houre arches on the plane.	Differ.
		d ′		d ′	d
7	5	1.10	8020.51	0.36	
.	½	8.40	8894.69	4.29	3.53
8	4	16.10	9173.87	8.29	4. 0
.	½	23.40	9353.38	12.43	4.14
9	3	31.10	9493.26	17.18	4.35
.	½	38.40	9614.83	22.23	5. 5
10	2	46.10	9729.32	28.12	5.49
.	½	53.40	9845.06	34.59	6.47
11	1	61.10	9970.86	43. 5	8. 6
.	½	68.40	10119.95	52.49	9.44
12	12	76.10	10320. 27	64.26	11.37
.	½	83.40	10666. 35	77. 50	13.24

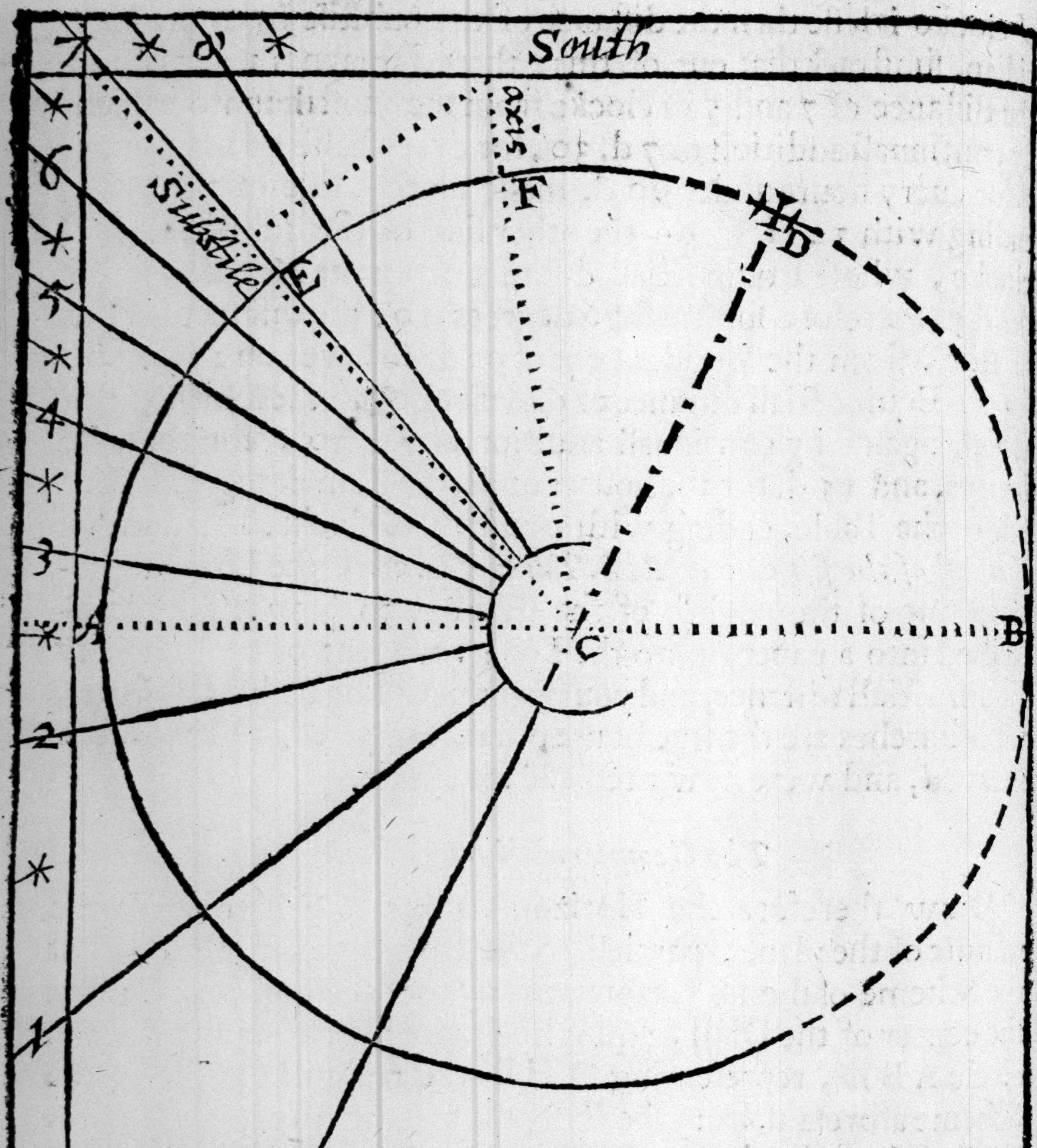
Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	The houre arches on the plane.	Differ.
		d ′		d ′	d ′
.	½	62 0	8756.91	3.16	
6	6	13.50	9102.99	7.13	3.57
.	½	21.20	9303.31	11.22	4. 9
5	7	28.50	9452.40	15.49	4.27
.	½	36.20	9578.19	20.44	4.55
4	8	43.50	9693.93	26.18	5.34
.	½	51.20	9808.43	32.45	6.27
3	9	58.50	9930.00	40.24	7.39
.	½	66.20	10069.88	49.35	9.11
2	10	73.50	10249.39	60.37	11. 2
.	½	81.20	10528.57	73.30	12.53
1	11	88.50	11402.74	87.44	14.14

Where-

Wherein becauſe 75 d. the Equinoctiall diſtance of 7 and 5 of clocke is leſſe then the diſtance of the Subſtile from the Meridian, ſubſtract that out of this, there remaynes 1 d. 10′. for the diſtance of 7 and 5 of clocke from the Subſtile: unto which by continuall addition of 7 d. 30′. for every halfe houre, and 15 d. for euery houre under 90 d. make up that ſide of the Table ending with 12 H. ½, on the other ſide of the ſubſtile is 6 of clocke, whoſe Equinoctiall diſtance from the Meridian is 90 degrees therefore ſubſtract 76 degrees 10′. the diſtance of the ſubſtile, from the Meridian out of 90 d. ſo have you 13. d. 50′. for the Equinoctiall diſtance of 6 of clock from the ſubſtile, unto which againe by continuall addition of 7 d. 30′, for the halfe houres, and 15 d. for the houres under 90 d. make up the other ſide of the Table, ending with 1 and 11 of clocke. This done *by the firſt of the fift caſe of R. S. Triangles*, adde the Logarithmeticall ſine of the heighth of the ſtile P R 30 d. 59′. (firſt tranſcribed into a paper) unto the Logar: tangent of every houres Equinoctiall diſtance, and you beget new Logarithm: tangents, whoſe arches are the true houre diſtances deſired, as I have often ſhewed, and were now needleſſe to repeate.

The Geometricall projection.

Draw therefore the Horizontall line A C B towards the middle of the plane, paralell to the baſe repreſenting A Z B of the Scheme of the 18 Chapter: in any part thereof, as at C place the center of the Diall, and with 60 d. of the chorde make the circle A B D, repreſenting A H B the reclining plane in the Scheme aforeſaid, from the Eaſt point of the Horizontall line A (by helpe of the chorde) ſet A 12. 64 d. 29′, the diſtance of the Meridian and Horizon, for the North part of the Meridian, but from B the Weſt part of the Horizontall line (more agreeable with the Scheme) upwards to D for the South part thereof, and draw the line D C 12, for the 12 of clocke houre: from D to E ſet 64 d. 26′, the diſtance betweene the Subſtile and Meridian Eaſtward from it, and draw the prickt line C E for the Subſtile; ſo ſhall B D of the Diall agree with A O of the Scheme, D E with O R, and C D the houre of 12 fall betweene them, as doth Z O S the Meridian in the Scheme. From the point E of the



North declining West 60 d. 0'.
Reclining 16. 0.

substile (by helpe of the chord) set the true houre distances both wayes upon the circle A B D, as you find them in the Table. Vnto every prick draw straight lines from the center C, so shal you have all the houre lines proper to this plane. Lastly, from E to F set

ſet of the heighth of the ſtile 30 d. 59′, and draw the line C F, repreſenting the Axis, which being erected at right angles, over the Subſtile C E, muſt point upwards to the North pole, ſo is the Diall fit for uſe, and muſt be placed according to the declination and reclination of the plane.

CHAP. XX.

To draw the houre lines upon a North reclining plane, declining East or West, which cutteth the Meridian betwixt the Æquator and Horizon.

The third Example.

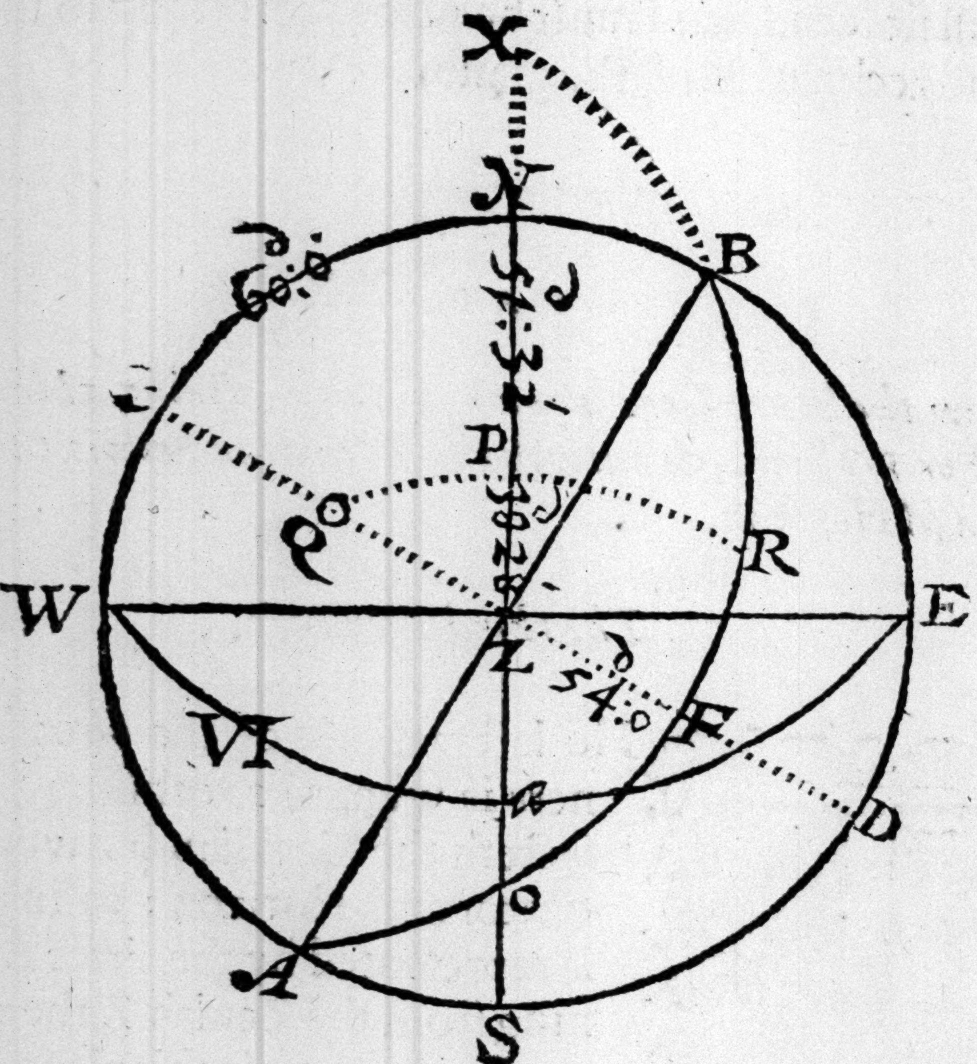
THe laſt varietie of the 6 reclining decliners is when the reclining plane interſecteth the Meridian betweene the Æquator and Horizon: as in the Scheme is repreſented by the circle A F B, reclining from the Zenith Z the angle Z A F 54 d. and becauſe this plane declineth ſo farre Weſterly, and cutteth the Meridian above the Tropique of ♑, the Sunne ſhall ſhine, both upon the inclining and reclining part thereof, according to the declination of the Sun, as by the ſeventh propoſition of the 34 Chapter more at large doth appeare.

The Demonſtration.

Now as you have done before, ſo muſt you in this Diall alſo (the making whereof differeth little from the former) ſeeke the foure things before mentioned, ere you can calculate the houre diſtances; *viz.* Firſt, the diſtance of the Meridian and Horizon. Secondly, the heighth of the pole or ſtile above the plane. Thirdly, the diſtance of the Subſtile from the Meridian; and laſt-

ly,

ly, the angle betweene the two Meridians, all which are easily drawne out of the Scheme adjoyning.



Data		Elevation of the pole N P	51 d. 32'.
	North	Declining West N C	60 d. 0.
		Reclining Z F	54 0.

Quæsita	1 distance of Meridian and Horizon A O		35 d. 31'
	2 the heighth of the Stile P R		54. 43
	3 distance of substile and Meridian	O R	123.19
		X R	56.41
	4 angle between the two Meridians	OPR	118.13
		XPR	61.47

Wherein A O is the distance upon the plane of the Meridian

N Z S from the Horizon at A. Secondly, R O is the distance upon the plane of the Substile Q P R from the Meridian N Z S. Thirdly, P R is the heighth of the pole or stile above the reclining plane A O R B: and lastly, O P R the angle betweene the two Meridians, Q P R of the plane, and N P S of the place.

The Arithmeticall calculation.

First therefore (as afore) in the triangle D Z S, having the side Z F, the reclination 54 d. and the quadrantall side Z D 90 d. and the side D S the declination, (which is the measure of the angle D Z S 60 d. you may *by the second of the fift Case* find out the side O F by the triangles S Z D, or O Z F, the complement whereof is A O the thing desired. For

			Logar.
1 *As the whole sine Z D*	90 d.	0	10000.00
Is to the sine of the side Z F	54	0	9907.95
So is the tangent of D S	60	0	10238.56
To the tangent of F O	54	29	10146.51

Therefore A O the complement thereof 35 d. 31′, is the distance of the Meridian and Horizon.

Secondly, In the same triangle you may find Z O *by the second of the eighth Case.* For

			Logar.
As the sine of the declination D S	60 d.	0	9937.53
Is to the whole sine S Z	90	0	10000.00
So is the sine of F O	54	29	9910.59
To the sine of Z O	70.	2	9973.06

Adde Z O 70 d. 2′ unto P Z 38 d. 28′. so you compose the whole line P O 108 d. 30′. whose complement to 180 d. is P X 71 d. 30′.

Thirdly, In the same triangle O P R you may find P R *by the fifteenth*

fifteenth of 4 Regiomontanus, *or second of* 14 *Finkius*, because the Hypotenusas and perpendiculars are proportionall each to other. For

			Logar.
As the sine of the Hypotenusa O Z	70 d.	2'.	0026.92
Is to the sine of the perpendicular Z F	54	0	9907.96
So is the sine of the hypote: P X the cõple: of P O	71	30	9976.96
To the sine of the perpendicular P R	54	43.	19911.84

Which 54 d. 43'. is the heighth of the stile or pole above the plane.

Fourthly, In the same triangle you may find R O *by the thirteenth of* 14 Finkius, *or second of* 4 Pitiscus: but because R O and P O be both of them more then quadrants, continue the sides R B and P N unto X, and find the Complement of R O in the triangle P R X. For

			Logar.
As the tangent of the perpendicular Z F	54 d.	0'.	9861.26
Is to the sine of the base F O	54	29.	9910.59
So is the tang. of the perpẽdicular P R	54	43	10150.21
To the sine of the base R X	56	42	29922.06

Which 56 d. 42'. or rather 123 d. 19'. the Complement thereof is the distance of the Substile and Meridian, reckoning from the South, R O being more than a quadrant, and R X the side found, which is the distance from the North.

Fiftly and lastly, in the triangle O P R you may find the angle at P, or rather in the triangle R P X, which is the Complement thereof, *by the second of the* 15 *or* 16 *Cases*. For

			Logar.
As the sine of R P	54 d.	43'	9911.84
Is to the tangent of R X	56.	42	10182.51
So is the sine of P R X	90	0	10000.00
To the tangent of R P X	61	48	10270.67

R P X being 61 d. 48'. is the angle counting from the North, therefore O P R the complement thereof to 180 d. which

is

is 118 d. 12′. the angle betweene the two Meridians reckoned from the South.

Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
4	8	1.48	8405.09	1.27	
.	½	9.18	9125.24	7.36	6. 9
3	9	16,48	9391.27	13.50	6.14
.	½	24.18	9566.18	20.13	6.23
2	10	31.48	9703.95	26.50	6.37
.	½	39.18	9824.59	33.44	6.54
1	11	46.47	9938.89	40.59	7.15
.	½	54.17	10055.10	48.38	7.39
12	12	61.47	10182.21	56.41	8. 3
.	½	69.17	10334.12	65. 8	8.27
11	1	76.47	10541.04	73.57	8.49
.	½	84.17	10911.37	83. 0	9. 3

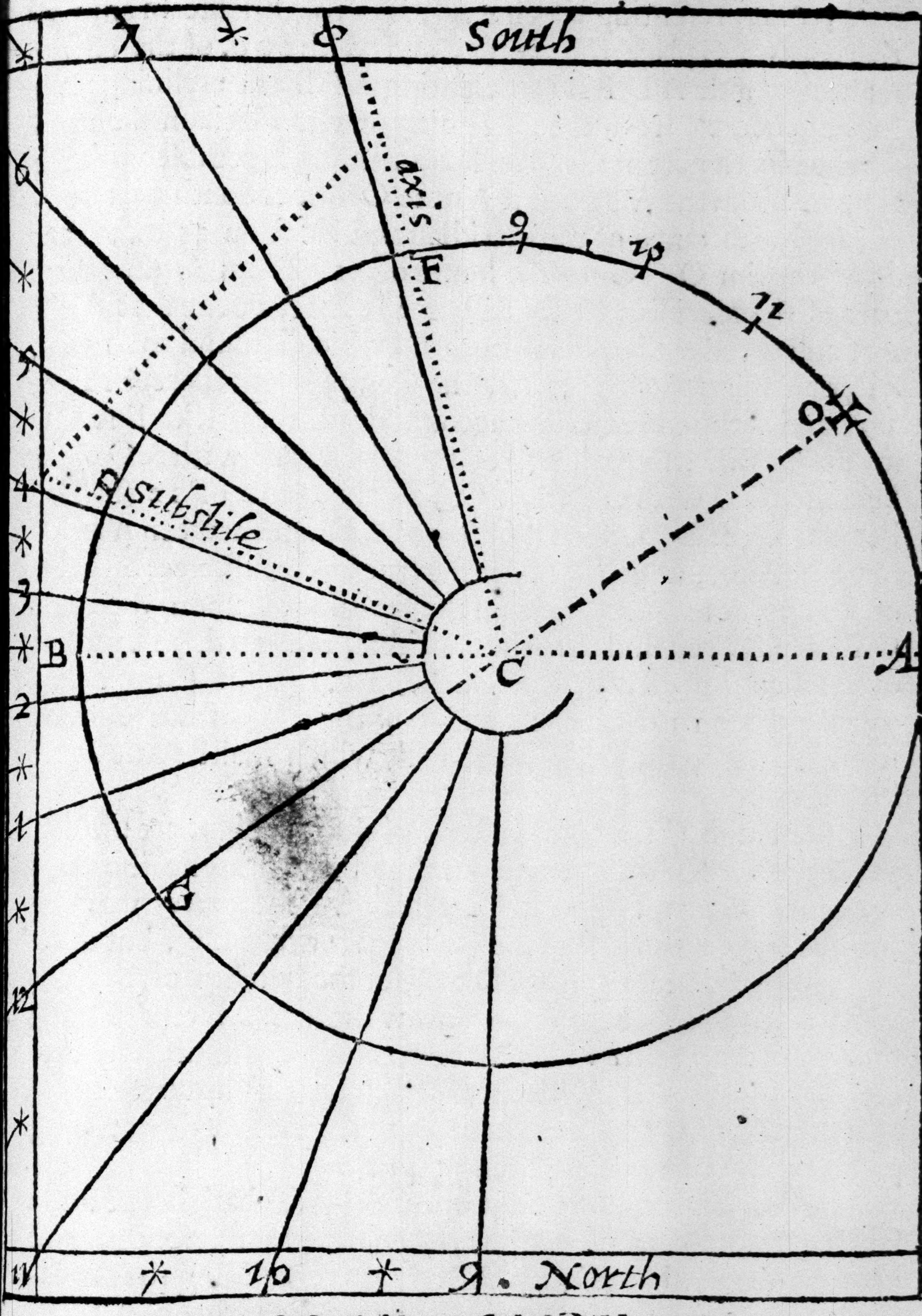
Houres and parts from the substile.		Equinoctiall distances.	Logarithmes of tangents.	Houre arches on the plane.	Differ.
		d ′		d ′	d ′
.	½	5.43	8912.30	4.40	
5	7	13.13	9282.63	10.51	6.11
.	½	20.43	9489.56	17. 9	6.18
6	6	28.13	9641.46	23.39	6.30
.	½	35.43	9768.58	30.25	6.46
7	5	43.13	9884.79	37.29	7. 4
.	½	50.43	9999.08	44.56	7.27
8	4	58.13	10119.71	52.48	7.52
.	½	65.43	10257.50	61. 4	8.16
9	3	73.13	10432.40	69.43	8.39
.	½	80.43	10698.43	78.41	8.58
10	2	88.13	11418.58	87.49	9. 8

These

These things prepared, I proceed to make the Table for the houre distances from the substile, wherein considering that the angle P betweene the two Meridians containeth 118 degrees. 13'. reckoned from the South, whereof 105 degrees is answerable to seven houres from the Meridian, you may conclude, that the substile of this Diall declining so farre West, must be placed betweene the seventh and eighth houres, reckoning from the South part of the Meridian, or betweene the fourth and fifth houres from the North part thereof, wherefore begin the Table either with 5 and 7, or with 4 and 8, as in this example is done. Vnto these houres and parts first set their Equinoctiall distances from the substile, which are thus found. Take *60* d. the æquinoctiall distance of foure of clocke from the Meridian, out of *61* d. 47'. the distance of the substile from the Meridian, and reserve 1 degree 47'. for the distance of 4 and 8 from the substile, unto which continually adde 7 degrees 30'. for the halfe houres, and 15 degrees for the whole houres under *90* degrees. The other side of the Table may be made up by the Complements to these, because the arches of every six houres *90* d. distant in the Æquator, are Complements each to other: this being done, take the Logarithme of 54 d. 43'. *99*11.85, the heighth of the stile, into a piece of paper, and adde it continually unto the Logarithmetical tangents of 16 d. 47'. *9479*.43. for 3. and *9*. of one side of the substile, and of 73 d. 13'. 10520.57. for *9*. and 3. on the other side of the substile, *6* ho. distant from the former: so have you new Logarithmeticall tangents, *viz*. *9391*.28: and 10432.41 which set downe in the Table. Lastly, seeke these new Logarithmeticall tangents in the Canon, so shall you find 13 d. 50'. and *69* d. 43'. the true houre arches upon the plane, which by helpe of the chorde are to be set both wayes from the substile, as hath beene often directed heretofore.

The Geometricall projection.

Now then to make this Diall upon the plane, draw the Horizontall line A C B about the middle of the plane, paralell to the base



North declining West 60. d. 0'.
Reclining 54. 0'.

base; & representing the line A Z B of the Scheme. In any part thereof as at C place the center, and with 60 d. of the chorde make the circle A D F B, representing A F B the reclining plane in the Scheme, from the East point of the Horizon B unto G for the North part of the Meridian, or (more agreeable with the Scheme) from the West point A unto O for the South part thereof; set the distance of the Meridian and Horizon 35 d. 31, and draw the line O C G for the houre of 12. From G the North part of the Meridian set the distance R X betweene the substile P R and the Meridian N Z S unto D, which is found to be 56 d. 41', or from the South part O, the Complement thereof 123 d. 19'. and at the end of either account draw the prickt line C D for the substile; so shall A O of the Diall agree with A O of the Scheme, O D with O R, and O C G the houre of 12 shall fall between A & D, as doth Z O S the Meridian between A and R in the Scheme; which done, set the true houre distances by helpe of the chorde both wayes from the substile at D upon the circle O F D G, as you find them in the Table, *viz.* 10 d. 51'. for five of clocke, 52 d. 48'. for 8 of clocke, 1 d. 27'. for 4 of clocke, 73 d. 57', for 11 of clocke, and so of the rest; from C draw streight lines to the pricks afore-said, which shall be true houre lines desired.

Now though all the houres after 8 of clock at night are uselesse, yet because their distances from the substile drawne thorough the center C to the opposite part doe give the houres wanting before noone, you may pricke them out for that use, but draw no lines to them; lastly from D to F set the heighth of the stile P R 54 d. 43'. either wayes, and draw the line C F, representing the axis of the World: Let C F be erected perpendicularly over the Substile line C D, with the side C F looking upwards to the North pole, so is the Diall fitted for use to the North declining plane 60 d. Westerly, reclining 54 d.

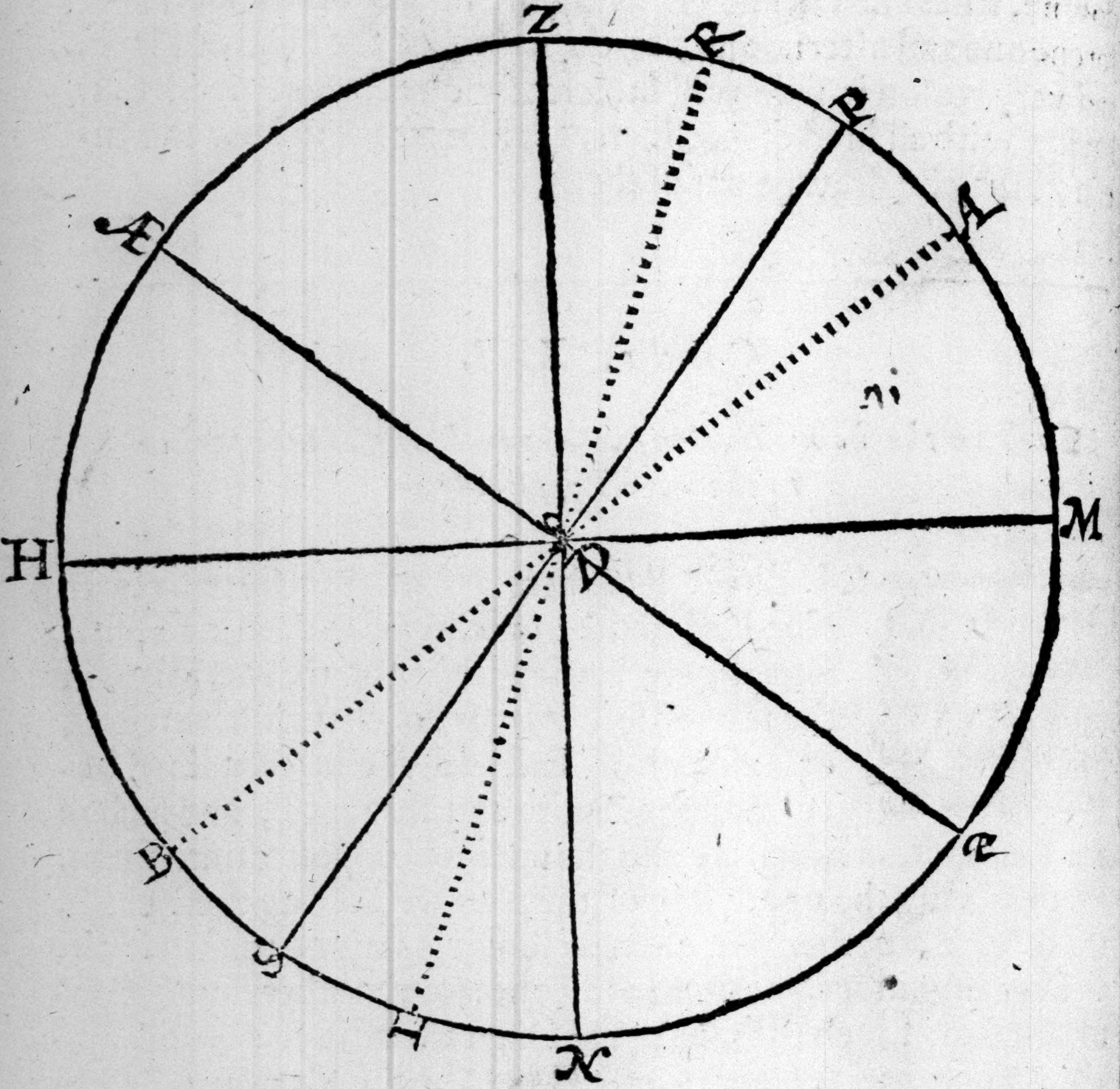
And thus have you againe at one worke (as hath beene often said heretofore) made foure severall Dials, *viz.* this for one, and his opposite South declining Easterly 60 d. inclining to the Horizon 36 d.: as also the North declining Easterly 60 d. reclining 54 d. and his opposite South declining Westerly as much incli-

inclining to the Horizon 36 d. onely turning the Dials up and downe, ſtiles and all, and changing the figures of the houres for forenoone and afternoone, as the nature of the Diall or Plane, and very reaſon it ſelfe will ſufficiently direct you. And thus having with all kind of Recliners, I will next ſhew how the Incliners may be drawne out of them.

CHAP. XXI.

To draw the houre lines upon any inclining plane oppoſite to the direct reclining.

ALL direct Recliners are of two ſorts, either North or South, or Eaſt and Weſt; in the firſt ſort, the reclination is part of the Meridian, in the ſecond ſort it is part of the prime verticall, or Azimuth of Eaſt and Weſt, contained betweene the Zenith and the plane, and ſuch as the Recliners are, ſuch are alſo the incliners oppoſite unto them, the one being the upper face of the plane reſpecting the Zenith, the other the nether face thereof looking downe to the Nadir, and varying indeed nothing at all one from another, but in contrapoſition of each part, as in the Diagram adjoyning will manifeſtly appeare. Wherein let Z H N M be the Meridian, Z O N the prime verticall, H D M the Horizon, Æ O D æ the Equinoctiall, P O S the axis of the World, P the North pole, S the South pole, Z the Zenith, and N the Nadir, R O I and A O B two reclining planes, the one reclining leſſe then the North pole, the other more; R D I, A D B two inclining planes, the one inclining leſſe then the South pole, the other more, the upper face in the recliners reſpecting the Zenith Z, as the nether face in the incliners doe the Nadir N as aforeſaid. Now as the North pole P, or rather the ſemiaxis O P is elevated above the reclining plane A O the angle P O A, ſo is the South pole S, or rather the ſemiaxis D S, depreſſed under the inclining part of that plane B D the angle S D B, equall to the former; but in the



other example as R D the inclining face of the plane R D I is elevated above the North pole P, ſo is O I, the reclining face of R O I, depreſſed under the South pole S, with like and equall angles at the center; from which analogie you may conclude, the Diall made to the one face of the plane will ſerve for the other, and the heighth of the ſtile to the one, is the ſame to the other, ſeeing both faces of the planes have like reſpect to each pole, only turning them up and downe reſpectively to their poles, *viz.* where the ſtile of the reclining plane reſpecteth the North pole, the ſtile of the oppoſite the inclining plane muſt reſpect the South pole; as in the firſt example, which is contrary in the ſecond.

In-

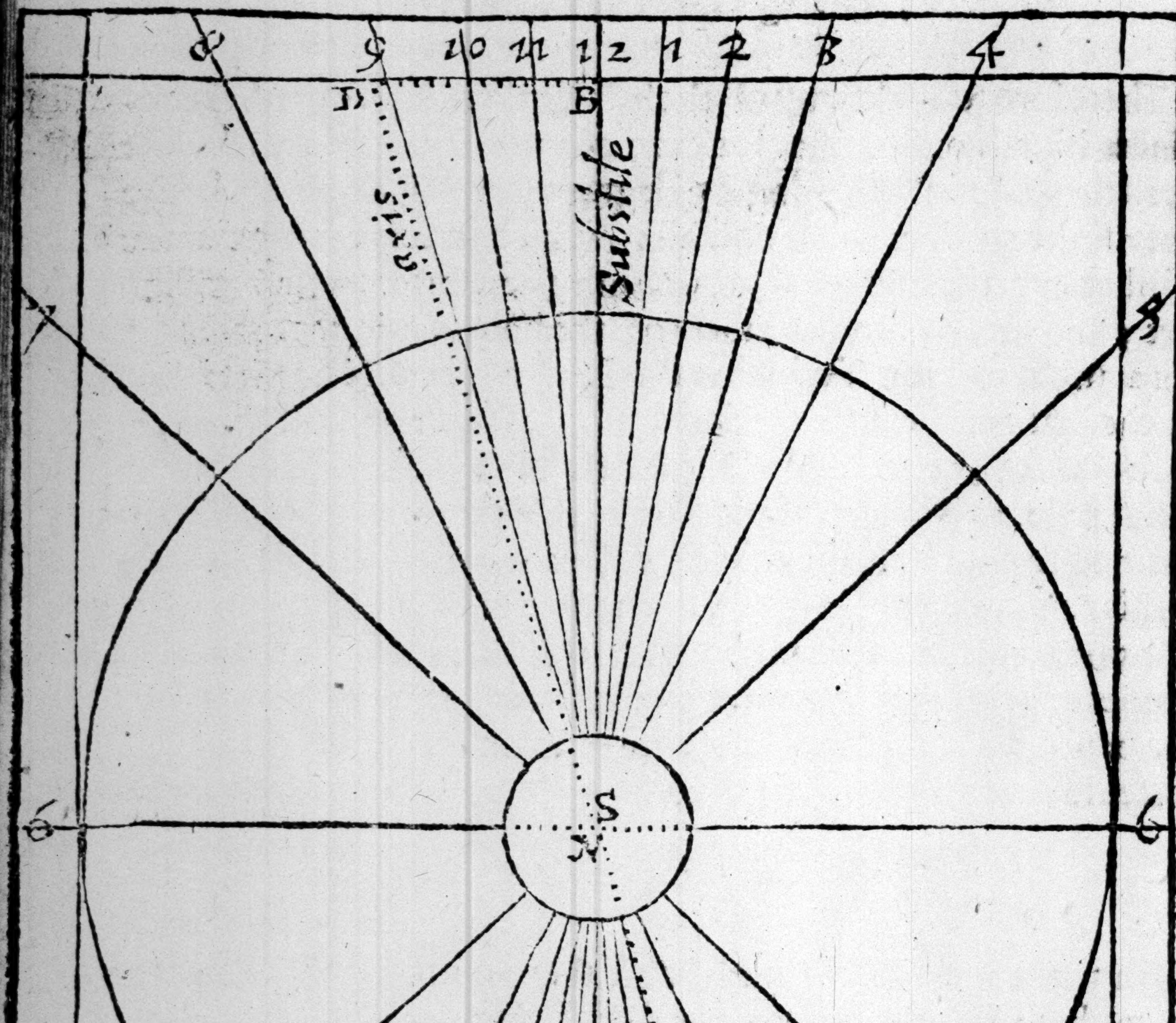
Inclining North and South.

Therefore to make any of these inclining Dials out of the recliners North or South as for example to the South plane of the twelfth Chapter reclining 55 degrees doe but draw the houre lines of the recliner, stile and all, (which in this example is the Diall above the line 6 S 6) thorough the center to the opposite part; and set the same numbers of the houres on the right hand of 12 in the incliner (which is the Diall under 6 N 6) that were on the left hand in the recliner, and contrary as the example doth plainly shew, and let the axis N C looke downe to the South pole, as S D doth up to the North pole, and the Diall is finished to the plane inclining 55 d. as was desired: Adde onely this remembrance, because the houres of the Incliner are here drawne upon the same plane with the Recliner, which doth properly belong to the under face thereof, therefore perforate the paper, and draw the same houres againe on the contrary side thereof.

Inclining East and West.

In the reclining East and West, there will be little difference from that which hath beene said of the former: First therefore insteed of the Meridian A N S B in the North and South, draw the Substile B R S A in the East and West thorough the center to the opposite part, which done, you may either set on all the houre distances, by helpe of the chorde, as they lie in the table of the 11 Chapter) from the substile of the Incliner S R B, as you formerly did from the substile of the Recliner S R A, changing the right hand houres into left, and contrary, so that the upper part of the Recliner may become the nether part of the Incliner, and the center S in the Incliner, respecting the North, as in the Recliner it doth the South; or else draw all the houre lines of the East Diall reclining thorough the center, as you did the substile, and you have at the same worke made both the East and West inclining Dials 35 d. as you desired; onely remembring

South reclining 55 d



North inclining 55 d.

for the West inclining to take the complements of the recliners houres to 12, and that but from three of clock afternoone, till eight at night, because the Sunne forsakes the reclining part of that plane 33′ after two, and then shines upon the opposite; Likewise for the East inclining both the houre lines and numbers serve as they stand, but must be taken (by perforation) on the other side of the paper. From hence you may collect that the reclining East and inclining doe both receive the Sunne together at his rising, and the reclining West, and inclining continue to shew the houres till Sunne setting: with this mutuall supply, that as the Sunne in ♋ forsakes the East reclining plane at halfe an houre past two afternoone, so doth it enlighten the West inclining plane at the same time, and as it forsaketh the East inclining plane at halfe houre after nine in the Morning, so doth it shine upon the West reclining plane at the same time, and each paire of them together make up the whole diurnall arch of the Sunne considered respectively.

CHAP. XXII.

To draw the houre lines upon any inclining declining plane opposite to the reclining declining.

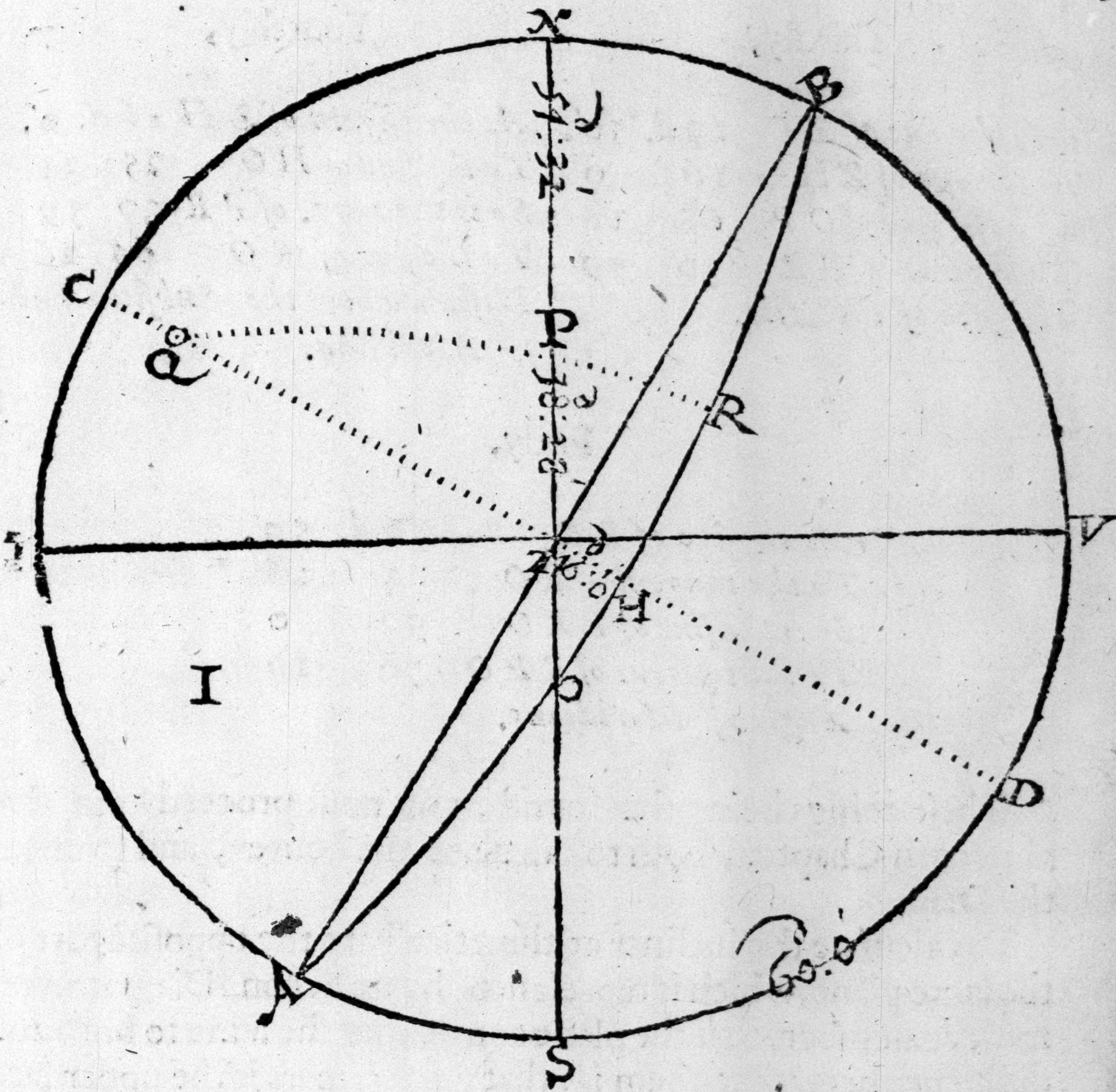
I Have formerly shewed the six varieties, incident to the reclining declining planes, and thinke it needlesse to instance in them all, how the incliners may bee deduced out of them, considering that one rule may be given for all, which will not much differ from the latter sort of the simple recliners, seeing the reclination is alike proper to each, and the deviation of the Substile from the Meridian, so directly agreeing in nature with the Decliners, that by the last precept of the seventeenth Chapter, they may be both reduced to one and the same.

If therefore any reclining Diall be so inverted, that the upper part thereof may become the nether, and after this inversion the

the right side of the recliner become the left side of the incliner, and contrary, the inclining Diall of the same declination shall be framed out of the reclining, or contrary; only the forenoone houres in the recliner will become the afternoone houres in the incliner; and againe, the afternoone houres of the upper Diall, the forenoone houres of the nether. To proove this rule to be agreeable both to reason and art (which may be also extended to all sorts of Dials whose houre lines are not paralels) I will describe two severall Schemes, the first proper to the reclining decliner, the second to the inclining Incliner, and set downe the parts of each, deducted out of its particular Scheme, that if you will be so curious, you may by this example calculate any declining inclining Diall, though for conclusion I will instance in drawing the one out of the other, as I have done in the former.

Let the example therefore be to make an inclining Diall to the nether face of the reclining plane of the nineteenth Chapter, which is a North declining West 60.d. reclining 16.d. The first Diagram proper to this example is taken out of the nineteenth Chapter aforesaid, wherein (as there is mentioned) N F S V is the Horizon, N P Z S the Meridian, F Z V the prime verticall, P the North pole elevated 51 d. 32′ Z the Zenith distant from the pole 38 degrees 28′, A O R B the reclining plane, declining from the North part of the Meridian the arch N C 60 degrees and reclining upon the azimuth, crossing the base at right angles, the quantity of Z H 16 d. 0′. the pole of the reclining plane so much elevated above the Horizon at C, as the plane it selfe reclineth from Z. Now there are foure things to be found out, (as in the nineteenth Chapter more at large doth appeare) before you can make the Diall *viz.* A O the distance of the Meridian and Horizon, P R the heighth of the Pole or Stile above the plane, R O the distance of the Substile and Meridian, and the angle O P R betweene the two Meridians. Wherefore,

First,



First,			Secondly,		
As the sine of Z D	90 d.	0'.	*As the sine of S D*	60 d.	0'.
To the tangent of D S	60	0	*To the sine of S Z*	90 d.	0
So is the sine of Z H	16	0	*So is the sine of H O*	25	31
To the tangent of H O	25	31	*To the sine of Z O*	29	50
Complement A O	64	29	*Adde Z P*	38	28
Meridian and Horizon.			*Fit O P*	68	18

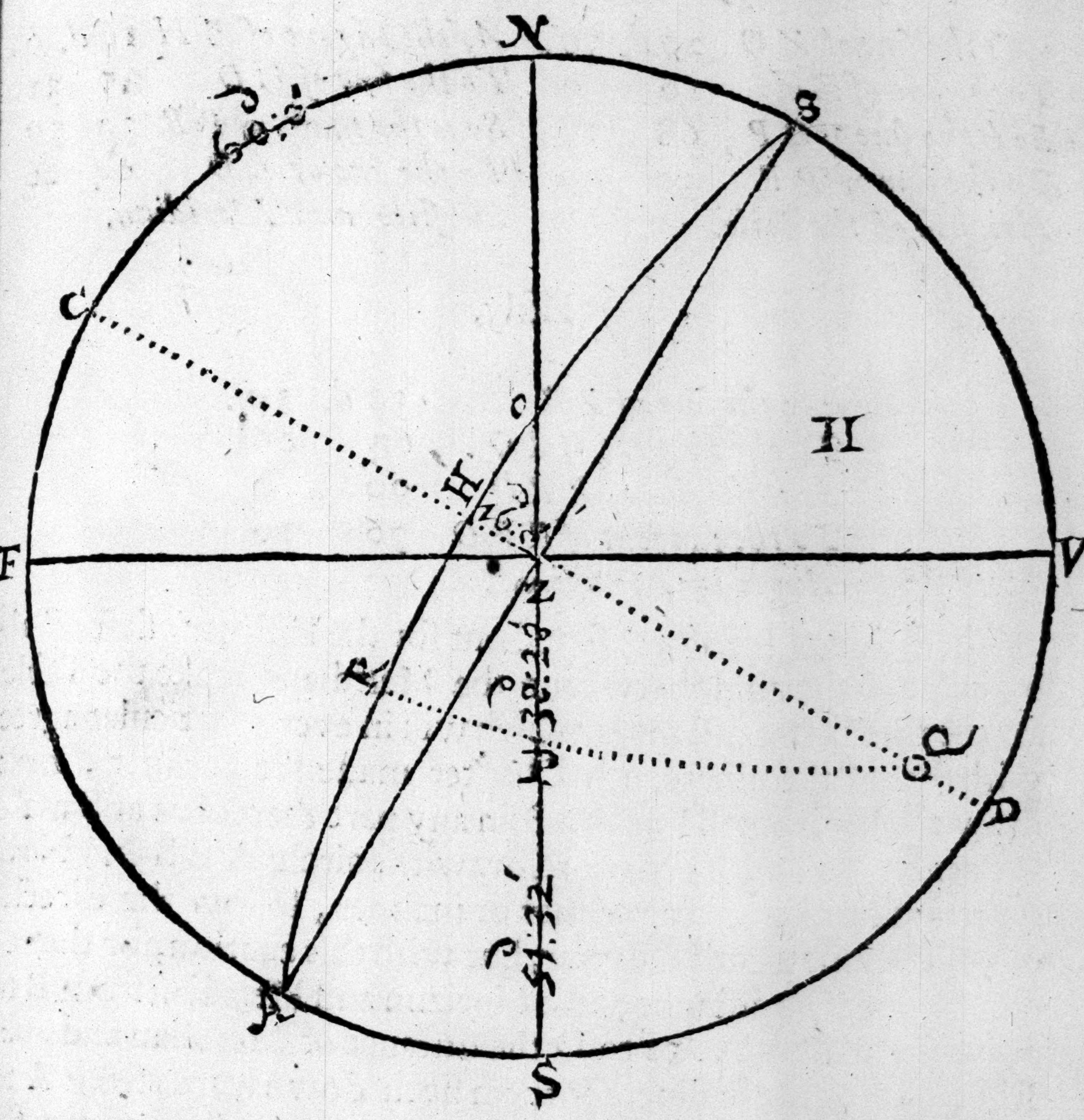
Thirdly,			Fourthly,		
As the sine of Z O	29 *d.*	50'.	*As the tagent of Z H*	16 *d.*	0'.
To the sine of Z H	16	0	*To the sine of H O*	25	31
So is the sine of O P	68	18	*So is the tang. of P R*	30	59
To the sine of P R	30	59	*To the sine of R O*	64	26
Heighth of the Stile.			*Distance of the Substile and Meridian.*		

Fiftly,

As the sine of P R	30 *d.*	59'.
To the tangent of R O	64	26
So is the sine of P R O	90	0
To the tangent of R P O	76	10
Angle of Meridians.		

These things being thus found, you must proceed as in the nineteenth Chapter, both to calculate the houres, and to make the Diall.

To calculate the incliner arithmetically to the opposite part of the same plane, which is represented by the second Diagram, you must remember, that the plane continuing the same to both, the difference betweene them is, that the recliners is the upper face thereof, respecting the Zenith, and the incliner the nether face looking downe to the Nadir; wherefore againe make the like Scheme to the former, but turned the contrary way, and in all things respecting the contrary part of Heaven, there in A R O B shall represent the inclining plane, Z the Nadir, P the South pole, S D the arch of declination 60 degrees from the South part of the Meridian at S, & inclining upon the Azimuth D Z C the quantity of Z H 16 degrees O P part of the Meridian under the earth between the plane and the South pole, and Q the pole of the inclining plane, so much under the Horizon at D, as in the recliner it was above it at C: and generally in all things like to the former, but in contraposition, therefore the *Quæsita* of the second Scheme can differ nothing from the first, when as all the



Data thereof doe agree, yet to avoid all ſcruple, you ſhall ſee the operations deduced out of the ſecond Diagram proper to the incliner, in every particular agreing with the firſt, which muſt needs conclude the truth of the former Rule as was propoſed.

First,

As the ſine of Z C	90 *d.*	0′.
Is to the tãgent C N	60	0
So is the ſine of Z H	16	0
To the tangent H O	25	31
Complement of O B	64	29
Meridian and Horizon.		

Secondly,

As the ſine of C N	60 *d.*	0′.
Is to the ſine of N Z	90	0
So is the ſine of H O	25	31
To the ſine of O Z	29	50
Adde to Z P	28	38
Fit O P	68	18

Thirdly,

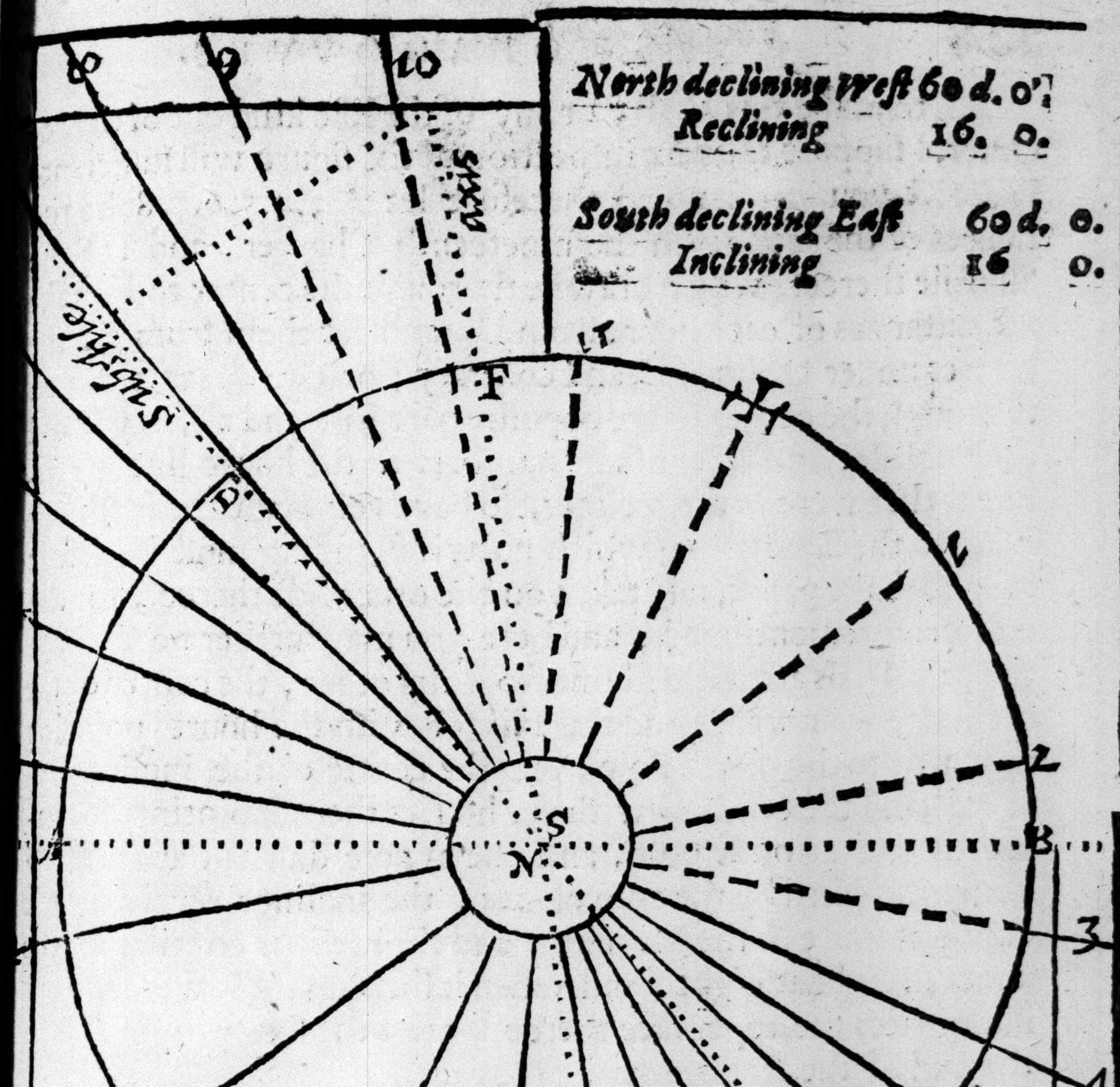
Thirdly,			Fourthly,		
As the sine of ZO	29 *d.*	50'.	*As the tāgent of ZH*	16 *d.*	0'.
To the sine of ZH	16	0	*To the sine of HO*	25	31
So is the sine of OP	68	18	*So is the tang. of PR*	30	59
To the sine of PR	30	59	*To the sine of RO*	64	26
Heighth of the Stile.			*Substile and Meridian.*		

Fiftly,

As the sine of PR	30 *d.*	59'.
To the tangent of RO	64	26
So is the sine of PRO	90	0
To the tangent of RPO	76	10
Angle of Meridians.		

These things (as afore) found out for the incliner, first of all by helpe of the angle betweene the Meridians make the Table for the true houre distances, which will in every particular agree with that of the nineteenth Chapter made for recliner, next draw the horizontall line A S B, in any part thereof as at S make the center, and with the chord draw the circle A E B D. Now if you will make either recliner or incliner, follow the directions of the nineteenth Chapter, but with this caution, for the recliner count the distance of the Horizon and Meridian from B to 12 upwards, & from 12 to D the distance of Meridian and Substile, but for the incliner set them both downwards from A to 12, and so to E (as the very Diagrams themselves with reference to the North and South parts of the Meridian will sufficiently instruct the ingenious practitioner.) The place of the Substile being thus found, take out of the nineteenth Chapter the true houre distances, set them from E both wayes for the incliner, as there you did from D for the recliner, stile and all, so have you done; adde onely the remembrance of the former Chapter (because I will make one Scheme serve two turnes) that since in this instance the inclining Diall is drawne on the same side of the plane with the recliner, which in the naturall position is opposite thereunto; therefore pricke the houre lines thorough the paper, and draw them againe on the other side, so shall they serve the turne, numbers, stile and all, without further alteration.

North


North declining West 60 d. 0'.
Reclining 16. 0.
South declining East 60 d. 0.
Inclining 16 0.
8
9
10
axis
Substile
F
11
1
2
S
N
B
3
4
E
5
Substile
G
6
axis
7
12
11
10
9
8

But to make this Diall, or any of the like kind out of the recliner, I suppose the bare inspection of the figure will sufficiently direct you. In a word therefore let A 3.4.5.6.7.8. be the houres of the recliner in the nineteenth Chapter, and D S the Substile thereof, which drawne thorough the center to E, take the distances of each houre from D, and set them from E, the houres under D above E, and contrary; or else draw them all thorough the center to the opposite part, stile and all, as you did the Substile, and set the same numbers to the houre lines continued, that were in the recliner, so have you made the inclining Diall to the same plane; which notwithstanding must be prickt thorough the paper, and taken on the other side thereof, for the reason aforementioned; and here you may further note, how the two Dials are diuided one from the other, the center of the recliner downwards, and the axis S F with the houres pointing upwards to the North Pole, but the center of the incliner upwards, and the axis N G with the houres therof pointing downwards to the South pole, and the whole diurnall arch of 16 houres supplied by the two planes, the incliner receiving the Sunne at foure in the Morning, and the recliner continuing the same till eight at night, and when it forsakes the lower face, it illuminates the upper face thereof, as by the sixt proposition in the end of the Booke may be proved.

Now for conclusion to verifie the generall rule delivered in the beginning of this Chapter, let the upper part of the recliner A S F be turned about till it become the nether part of the Incliner B N G, and after this convertion let the houres on the right hand of the Substile neere D in the recliner be made the houres on the left hand of the substile neere E in the incliner, and contrary; which may easily be done by supposing A F S to be carried about the center S horizontally (with the rest of the Diall) till F be placed in G, and A in B, and then you shall see the inclining is the very same that the reclining was, and therefore by good reason the one may be framed out of the other.

CHAP.

CHAP. XXIII.

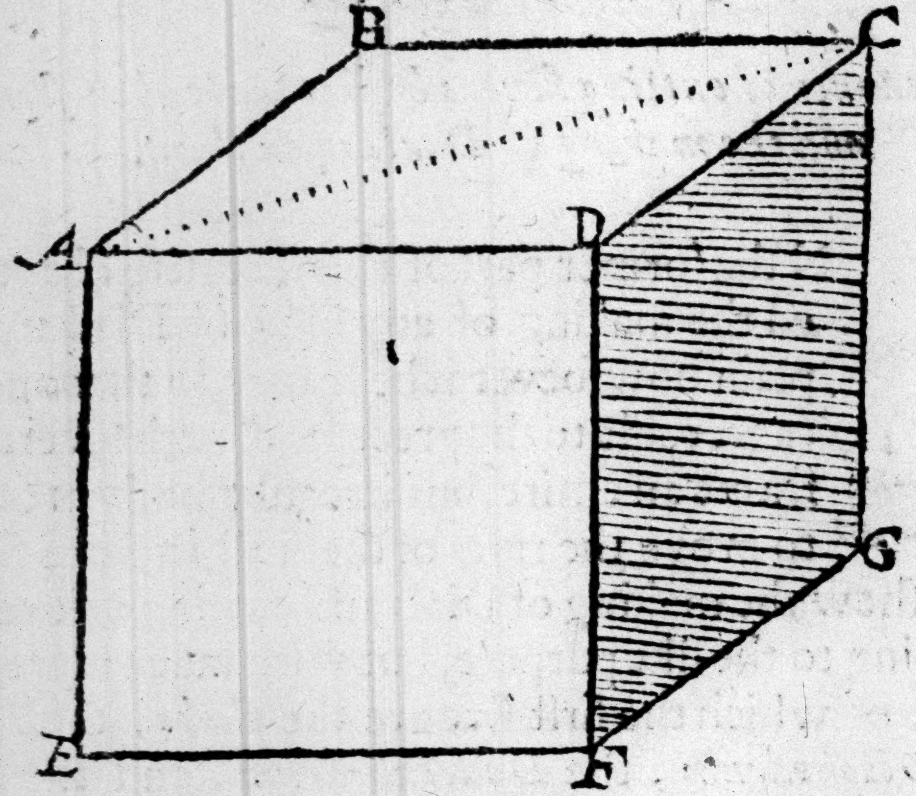
Of the manner of cutting divers bodies in wood or stone, and the making of Dials upon them.

IN the former part of this Treatise I have shewed the making of any kind of Diall upon any plain howsoever it be situate, so that one might (agreeable to the precepts of each several plane) frame an entire, but irregular body at one view to prove the rules of them all, in stead thereof I will rather shew the making of Dials and cutting of seven other bodies, tending to the like purpose, but with much more delight and variety, of which the first five are the *Cube*, the *Tetrahedrum*, the *Octohedrum*, the *Dodecahedrum*, and the *Icosahedrum*, the five regular bodies inscriptible in a Sphere, the other two, the one of 12, the other of 30 *Rhombes*, devised by my worthy friend Master *Henry Briggs* our English *Archimedes*, from whom I received directions for the cutting of these two bodies, and some of the rest also, and doe in memory of him commend it to posterity.

Now because the Cube is as it were the moles, or lumpe, out of which the rest are contriued, I will first speake thereof, though there be little curiosity belonging to it.

How to cut the Cube.

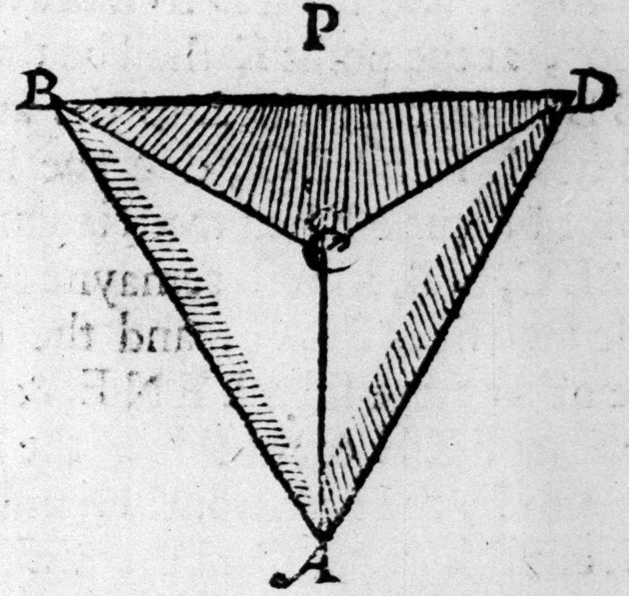
A Cube is a solide bodie comprehended of six equall squares, as are A B C D, A D E F, and D C F G, &c. the cutting of this body is plaine, by the definition: for let every side of every square be equall, as A B to D F, A E to C G, &c. and you make a Cube of what greatnes you will. This body is capable of five ordinary Dials, the sixt square being the base to stand upon, wherfore if you set the side A D E F South, then will the side opposite thereto be North, D C F G East, and the side opposite thereto West, and A B D C horizontall, all which Dials are ready made in

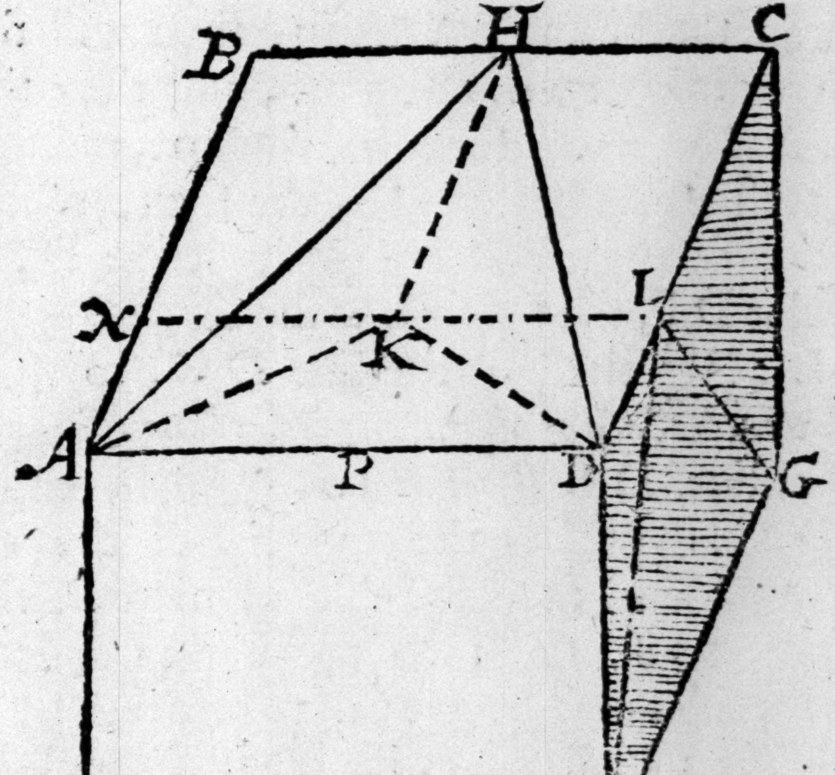


in the *6.7.8.* and *9.* Chapters; but if you place any angle of the horizontall, as A D G South, then will every side decline 45 d. for if you draw the Diagonall A C representing the line of East and West, and suppose the two sides of the Cube C D and A D to move upon the centers A and C from the Diagonall A C, where they have no declination at all, till they crosse each other at right angles in D, there shall be made a right lined right angled Triangle, whose three angles are equall to two right angles by *the 32 of the 1 Euclid. and 49 of the 1 Pitiscus:* but the angle D is a right angle by the worke, therefore the angles at A and C subtended by equall sides are 45 d. a piece, and consequently each side declineth from the line A C 45 d. wherefore D C F G is a South declining East 45 d., and A D F E, a South declining West as much, and their opposites North declining East and West 45 degrees, all which foure Dials are in effect but one, ready made in the tenth Chapter, observing the cautions therein mentioned.

How

How to cut the Tetrahedrum.





The *Tetrahedrum* is a solid body comprehended of foure e-quall equilaterall Triangles, as are A C B, A C D, and D C B, to cut this body, you must first make a paralellepiped B E F C: let the breadth A D be 10000, and the heighth A E the root of $\frac{2}{3}$, 81649, and the length AB the root of $\frac{3}{4}$, 86602, upon the up-per

per face and base thereof draw two opposite equaliter Triangles as is A D H, divide the perpendicular thereof P H equall to A B, or D C, into three severall parts, let the third part thereof $2\underline{8867}$ from A to N, and from D to L draw the line N L in the middle whereof, at the point K shall be the vertex C, or top of the solide A B D; from the point L to the angles F and G draw two straight lines L F and L G, doe the like on the opposite side by the point N, cut off the two triangular portions L D F, N A E, and G L C, N B, so will remayne the solide body called *Prisma*, whose two sides F L G, and the opposite, are equall Triangles, the other three sides L F N E, &c. are paralelograms; Next by the points F K H & the side of the Triangle F H drawn in the base, as also by the points E K H, and the other side of the Triangle E H, cut this *Prisma*, and there will come forth the solid body A C D B, the *Tetrahedrum* desired. The body being thus prepared, set the angle A South, then will the side B C D be a North reclining 19 d. 28′. 16″., and the other two sides A C B and A C D South declining 60d. 0′., reclining as the former, the reclination is proved by the figure, whereon the body is cut. In the Triangle F D L right angled at D, you have the perpendicular D F, the heighth of the figure $8\underline{1649}$, and the lesser side D L $2\underline{8867}$ the $\frac{1}{3}$ of the line D C, to find the angle at F, *by the seventh Case of right angled plane triangles*: or if you make F D radius, D C shall be 10, $\underline{606596}$, and D L $3\,\underline{5355}$, the $\frac{1}{3}$ of D C shall bee the tangent of the angle L F D, which being found in the Table of naturall tangents, shall give 19 degrees 28′. 16″: the reclination desired. The declination of the sides may be proved to be 60 d. by the angles, for *by the 53 of the 1 of Pitiscus*, if a plane Triangle be inscribed in a circle, the angles in the periphery opposite to the Circumference, are $\frac{1}{2}$ the Circumference opposite to the angles, but every side of an Æquilater Triangle subtendeth 120 d. of the Circumference, therefore every angle the $\frac{1}{2}$ thereof 60 d. if therefore you suppose B D of the solid to be paralell to the line of East and West, and that D A and B A move from that line upon the centers D and B, till they crosse each other in A, making the sides

equall,

equall, the angle shall be also equall, *by the fift of the first of Piriscus*, each containing 60 d. as aforesaid. Having the reclination of the North plane, the Diall proper thereto is to be made like the second kinde of the 14. Chapter, whose houre distances from the Meridian are as followeth.

Houres and parts from the Merid.		Houre arches on the plane.		Houres and parts from the Merid.		Houre arches on the plane.	
		d	'			d	'
12	0			9	3	40	17
0	1/2	6	22	0	1/2	47	50
11	1	12	48	8	4	55	44
0	1/2	19	21	0	1/2	63	57
10	2	26	4	7	5	72	27
0	1/2	33	2	0	1/2	81	10

North reclining	19 d.	28'.	16".
Adde thereunto	38	28	0
The heighth of the stile	57	56	16
The Logar.	9928. 1254.		

The other two South declining reclining have the same Diall serving for both, changing but the position of substile and houres, as the cautions of the tenth Chapter will direct you, and is to be made by the rules of the 16 Chapter, the particulars whereof with the houre distances from the Substile are as followeth.

Houres from the Substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	'	*Houres.*	d	'
0 ½ 0	0	4	8 . 4	0	10
9 . 3	0	19	½	0	25
½	0	35	7 . 5	0	41
10 . 2	0	52	½	0	58
½	1	10	6 . 6	1	18
11 . 1	1	32	½	1	42
½	2	0	5 . 7	2	13
12 . 12	2	37	½	2	55
½	3	31	4 . 8	4	0
1 . 11	5	0	½	5	56
½	8	8	3 . 9	10	36
2 . 10	19	26	½	29	2

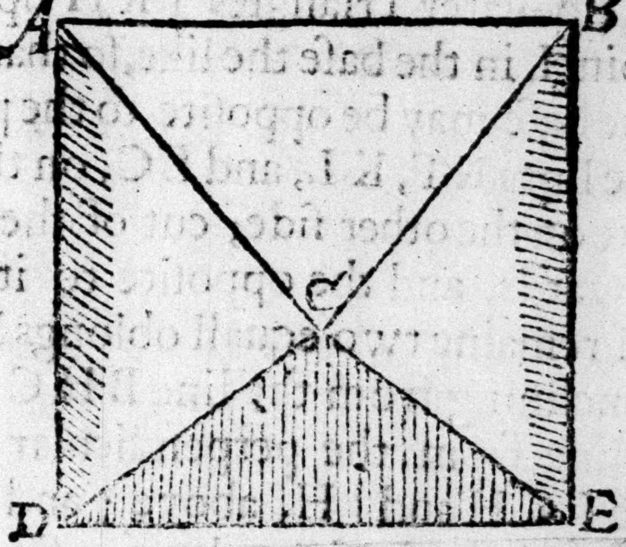
South reclining	19 *d.*	28'.	16".
Declining East and West	60	0.	0.

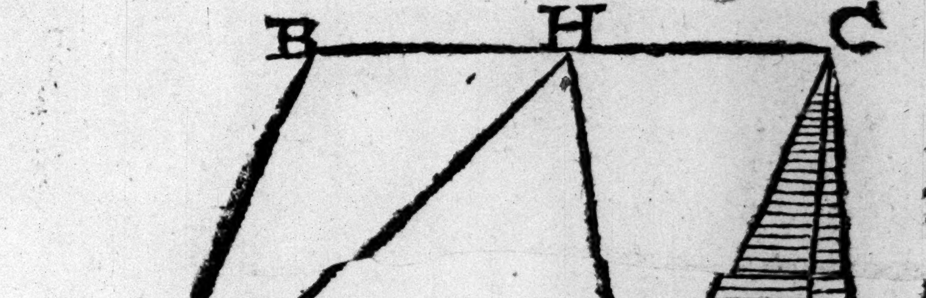
1 The arch of the plane betwixt the Meridian and Horizon. 60 d. 0'. 0".
2 The arch of the Meridian betwixt the Plane and the Zenith. 35 52.
3 The heighth of the Stile or Pole aboue the plane 50 53.
4 The distance of the Substile from the Meridian 2 36 56.
5 The angle betweene the two Meridians. 54 46 43.

Therefore the Substile falleth betweene 8 and 9 of the East Diall betweene 4 and 3 of the West 1 d. 50'. 53". *Log.* 8508. 5170.

How to cut the Octohedrum.

The *Octohedrum* is a solid body comprehended of eight equall Equilater: Triangles, as are A C B, A C D, B C E, and E C D; To





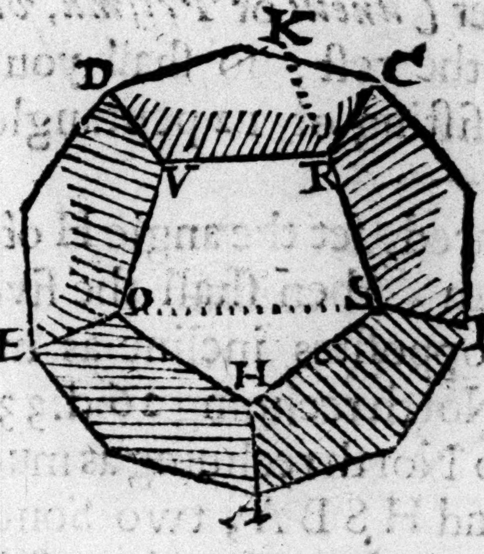
To cut this body, you may first make a Paralellepiped B E F C let the breadth thereof B C or A D be 100000 and the heighth thereof A E or C G the root of $\frac{2}{3}$ as afore 81649 and the length thereof B A or F G, the root of $\frac{3}{4}$ more by $\frac{1}{3}$ thereof 115470. Let A I and D K and L G be 28867 one fourth of A B or F G, by

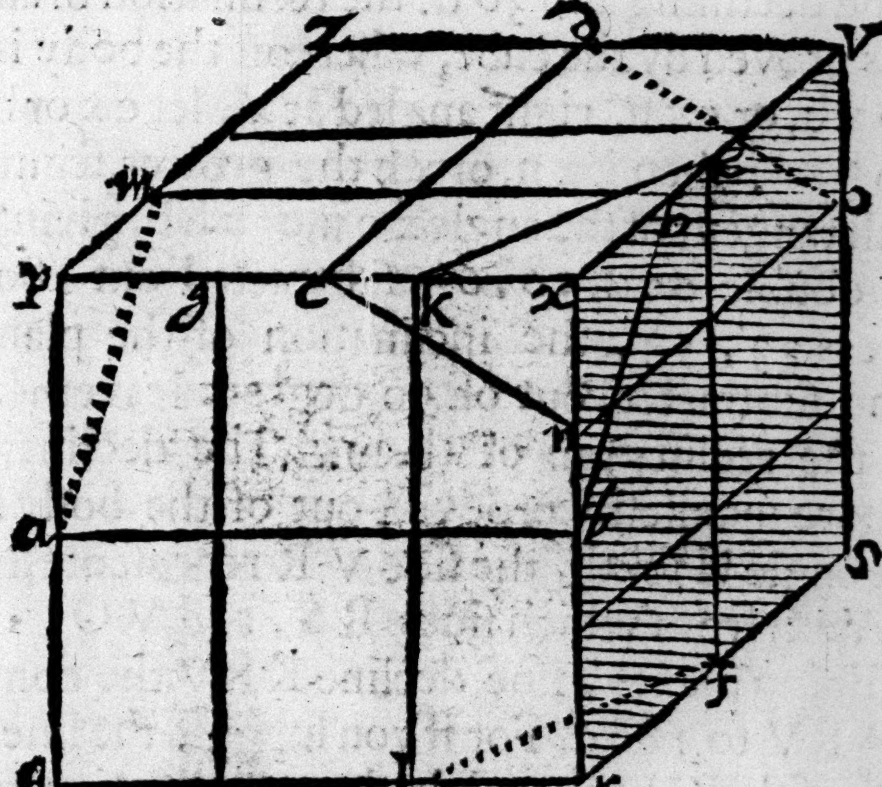
by which draw the line I K upon the superficies, and the like by L in the base make two Equilater Triangles I K H upon the superficies, & from the point L in the base the like, so that the point N of the Triangle in the base may be opposite to the point H of the superficies, draw the lines K F, K L, and L C, on the one side of the figure, and the like on the other side; cut of the triangular portion I K F E downwards, and the opposite to it L G C B upwards, and there will remaine two equall oblongs K I B H C, and L F N E, the base inclining from the line B H C as much as the superficies doth recline from the perpendicular of E N F; next cut of the portions L K H and I H, above; and L K N and I N, by the triangle beneath, so shall you have at six cuts the solide of eight Equilater triangles A B C D E desired. The body being thus prepared, set the angle C of the Horizontall A C B South, and the same Dials of the *Tetrahedrum* will serve for the *Octohedrum* also, for the plane D C E shall be a South inclining, and his opposite a North reclining 19 d. 28′. 16″. as may be proved by resolving the right angled triangle F D K, or L G C. In this parallelepiped, equall to L D F of the former, D K, and D L, being the naturall tangent of the angle F in both of them, supposing D F to be the radius, the planes D C A and E C B shal decline 60 d. and recline as the other, and their two opposites decline and incline as much, as were easily proved, but that the bodies themselves, joyning the reclining side B C D of the *Tetrahedrum* to the inclining side D C E of the *Octohedrum*, will plainly demonstrate the same, the Dials then being already calculated for the one, it were needles to reiterate the work for the other, onely for the inclining planes, I referre you to the 21 and 22 Chapters.

How to cut the Dodecahedrum.

The *Dodecahedrum* is a solide body comprehended of 12 equall Equilater pentangles, as are H S R V O, H S B A, and H O E A &c. To cut this body, you must first make a Cube as is p q r s v, divide each side into halfes, as p q at a b: r s at f E: and x p at c d. Let each halfe p a. x e. and r f be the radius

or





or 100000 divided by extreame and meane proportion p g, x h, and $\overline{\text{V O}}$ shall be 61803 the greater Segment, and g c, h e, and and n b 38196 the lesser Segment, and so must the rest of the sides be also divided, but with this caution, that the middle lines and segments of every side conterminous be drawne crosse to other, as those of p q, r x, crosse to those of x r, S V, and they againe crosse to them of p x, V Z. yet every opposite side paralell to other; From the greater segment of the one side, to the middle line of the other, draw streight lines crosse the body, as are n c, k e,

 and

and h b. Cut off each trianguler *Cuneus* or *Prisma, viz.* n odc, LKfe, and m h b a, and so of the rest; so shall you at 12 cuts frame the *Dodecahedrum* consisting of 12 pentangles, as is represented by the first figure.

The body being thus prepared, set the angle H of the Horizontall plane H S R V O South, then shall the five superiour planes recline, and their opposites incline as much: *viz.* R V D K C shall be a direct North reclining 26 d. 33′. 54″., and V O D E, and R S B C, two North reclining as much, and declining also 72 d. H O E A, and H S B A, two South reclining as much, and declining also 36 d. the reclination of all five being the same, is proved by the cube, whereon the body is cut: for in triangles b x h, or c x n, right angled at x, let c x or b x, be the radius, 10 0000, then is x n, or x h the greater segment 6 1803 the naturall tangent of the angle x c n, or x b h, giving 31 d. 43′. 3″. whose double 63 d. 26′. 6″. subtracted out 180 d. leaveth 116 degrees 33′. 54″. the inclination of the planes each to other, and subtracted out of 90 degrees leaveth 26 degrees 33′. 54″. the reclination of them. The declination of the planes is more manifestly prooved out of the body it selfe: for setting the angle H south, the side V R representeth the line of East and West, from which sides R S, and V O, of the two North reclining planes, doe decline K R V the complement of the angle S R V to 180 d. For if you suppose the line S R K, lying upon the side R V, where it hath no declination, to be moved about upon the center R, till it returne into the due position, the angle S R V shall be 180 d. $\frac{3}{5}$ of a semicircle, subtended by the 3 sides S H, H O, and O V, containing 216 d. *by the* 11 *prop. of the* 4 *Booke of Euclide*, and K R V 72 d. the complement thereof to 180 d. which is the true declination of those two planes, and of the two inferiour opposite to them.

Now againe, suppose the sides H S, or H O, of the two South reclining planes, to lie in the prickt line S O, paralell to R V then shall each line turning upon his center S and O, unto their due positions decline from the line S O the quantity of the angle H S O or H O S which being subtended by the sines H O

or H S, containing 72 degrees, the fift part of the circle the angle it selfe shall bee but halfe so much *by the 53 of the 1 of Pitiscus, viz.* 36 d. the declination of those two planes, and their opposites; and if the angles at O and S be but 72 d. the angle H equall to the angle R is 108 d. *by the 49 of the first of Pitiscus:* or if you suppose a Meridian line from K H to be drawn perpendicular to O S and V R the angle K H S subtended by S R, and $\frac{1}{2}$ of V R is 54 d. the complement of h S O desired. Having the reclination of the North plane, the Diall to it is to be made like the second kinde of the 14. Chapter, whose houre distances from the Meridian are as followeth.

Houres and parts from the Merid.		The houre arches on the plane.		Houres and parts from the Merid.		Houre arches on the plane.	
12	0	6	48	9	3	42	12
.	$\frac{1}{2}$	13	39	.	$\frac{1}{2}$	49	45
11	1	20	35	8	4	57	30
.	$\frac{1}{2}$	27	38	.	$\frac{1}{2}$	65	0
10	2	34	49	7	5	73	32
.	$\frac{1}{2}$			.	$\frac{1}{2}$	81	44

VRDC. North reclining	26 *d.* 33'. 54''.
Adding to it	38 28 0
The heighth of the stile	65 1 54
The Logar.	9957. 3875

The two North recliners and their opposites declining 72 *d.* 0'. have the same Diall serving for all foure, changing the position of the substile and houres, as is heretofore directed, and are to be made by the rules of the 20 Chapter, the particulars whereof with the houre distances are as followeth.

Houres from the Substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	'	Houres.	d	'
6 . 6	2	10	½	1	42
½	6	9	5 . 7	5	43
7 . 5	10	17	½	9	49
½	14	41	4 . 8	14	12
8 . 4	19	30	½	18	58
½	24	55	3 . 9	24	18
9 . 3	31	7	½	30	25
½	38	26	2 . 10	37	35
10 . 2	47	9	½	46	8
½	57	35	1 . 11	56	22
11 . 1	69	51	½	68	26
½	83	37	12 . 12	82	5

RSBC, and VODE, North reclining 36 d. 33'. 54".
Declining also East and West 72 0 0.

1 The arch of the plane betwixt the Meridian and the Horizon 36 d. 0'. 0".
2 The arch of the Meridian betwixt the plane and the Zenith 58 16 57
3 The heighth of the stile or pole above the plane 31 28 20
4 The distance of the Substile from the Meridian 82 4 40
5 The angle betweene the two Meridians 85 50 41

31 *d.* 28'. 20". *the Logar.* 9717. 7414.

The two South recliners and their opposites declining, 36 d. 0'. have also the same Diall serving for all foure with the former cautions, and are to be made by the rules of the 16 Chapter, the particulars whereof with the houre distances from the Substile, are as followeth.

Houres

Houres from the substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	'	*Houres.*	d	'
10 . 2	0	11	½	0	34
½	0	57	9 . 3	1	20
11 . 1	1	44	½	2	9
½	2	36	8 . 4	3	3
12 12	3	34	½	4	6
½	4	41	7 . 5	5	21
1 . 11	6	6	½	6	56
½	7	57	6 . 6	9	7
2 . 10	10	36	½	12	26
½	14	53	5 . 7	18	13
3 . 9	23	15	½	31	9
½	45	32	4 . 8	71	42

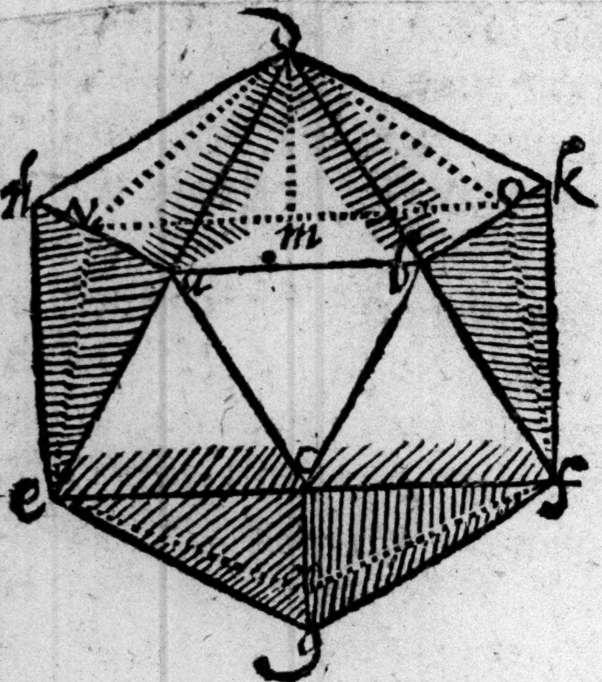
H S B A and H O E A South reclining 26 *d.* 33'. 54''.
Declining East and West 36 0 .0

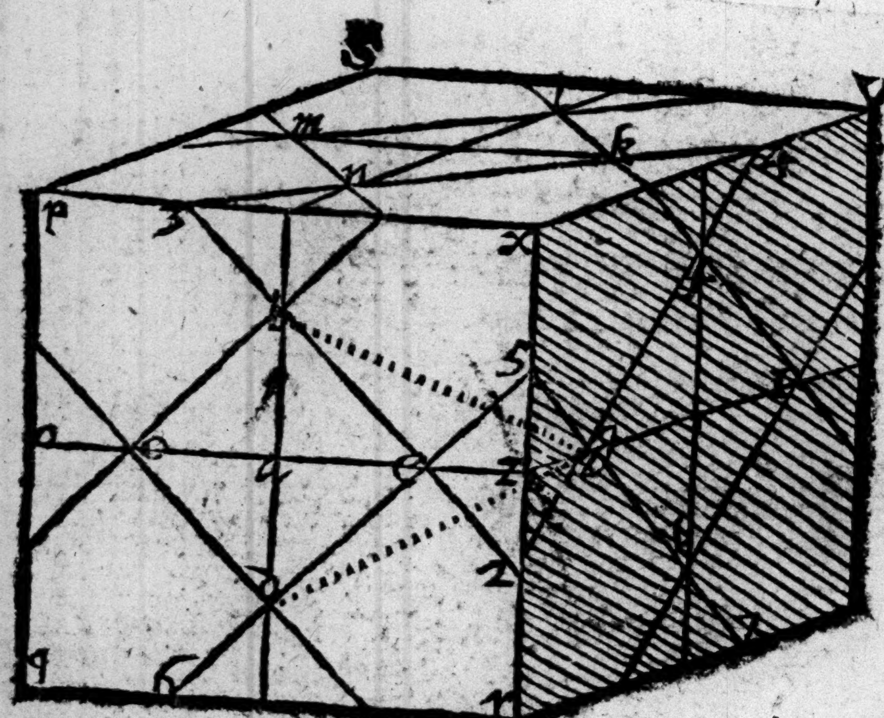
1 The arch of the plane betwixt the Meridian and Horizon. 72 d. 0'. 0''.
2 The arch of the Meridian betwixt the Plane and the Zenith. 31 43 3
3 The heighth of the Stile or Pole aboue the plane 5 44 15
4 The distance of the Substile from the Meridian 3 33 36
5 The angle betweene the two Meridians. 31 53 40

5 *d.* 44'. 15''. *the Log.* 8999. 8739.

How to cut the Icosahedrum.

The *Icosahedrum* is a solid body comprehended of twenty equall equilaterall Triangles, as are a b c, a b d, a c e, c b f, &c. There are two wayes to cut this body, the one in the very same manner as the *Dodecahedrum* was cut, drawing the parallell lines upon the *Cube* at the distance of the lesser segment, as there you draw them at the distance of the greater segment. The other way is thus; divide each side of the *Cube* p q r s v into



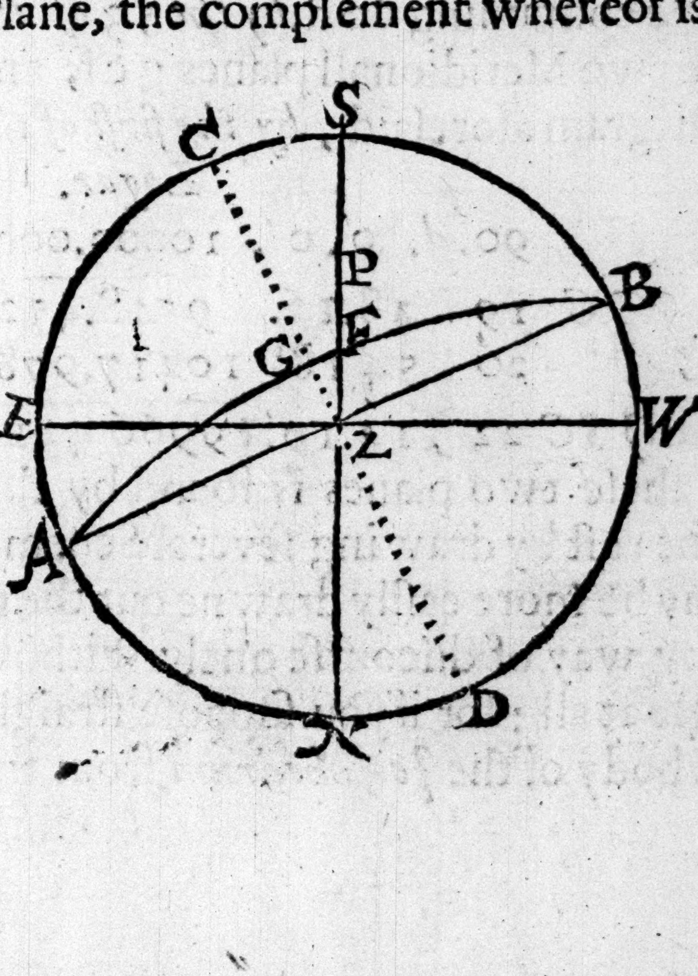


to halfes, and draw straight lines, crossing at right angles, as are b d, c e, f h, g i, k m, and l n: then making p o, o a halfe the side, the radius 100000, let a c the greater segment 61803 be set from a upon each middle line, to crosse at b c d e and f g h i, &c. by each two prickes, *viz.* b e, c d, b c, and e d, draw straight lines, crossing each other at right angles, round about the Cube, so shall you have 8 equilaterall triangles, such as are 2 3 4 & 5 6 7 &c. by which every corner being cut off, there will remayne six squares, such as b c d e, f g h i, k l m n, and eight sexangles, then shall b d be the base, and the point g of the next square the ver-

tex

tex to cut out the triangle b d g; and g i shall be the base, and k the vertex to cut out the triangle g i k, and k m the base, and b the vertex, to cut out the triangle k m b, and these three being cut, will leave a fourth triangle betweene them k b g, and so of the rest.

The body being thus prepared, set the angle c of the horizontall a b c South, then shall a b d, be a direct North declining 81 d. 11′. 23″. and the opposite South inclining as much, a c e, and c b f, are two South reclining as the former, but declining also 60 d. the other six planes conterminous with these three doe all recline alike 19 d. 28′. 16″. whereof the two Meridionall g c e, and g c f doe also decline 22 d. 14′. 29″, the two backward Northerne planes k b d, and h a d doe decline 37 d. 45′. 41″. and the two intermediate Septentrionall planes b k f and a h e doe decline 82 degrees 14′. 19′. and as these, so doe their opposites decline and incline as much. The reclination of the three superiour planes may be proved by the Cube, whereon the body is cut. For as the greater segment of the halfe side is the naturall tangent of an angle, the double whereof subtracted out of 90 d. leaveth the reclination of the planes in the *Dodecahedrum*, so is the lesser segment Z E or Z g in this Cube 3^{8196} the naturall tangent of the angle Z a g in the Cube, or z g c in the body, 20 d. 54′ 18″., the arch of the Meridian betwixt the Zenith and the Plane, the complement whereof is Z c g, the angle betweene the Meridian & the Plane, supposing a perpendicular raised from g to meet with the Horizontall line in C continued, double the angle Z a g, you have 41 d. 48′. 37″, which taken out of 180 d. leaveth 138 d. 11′ 23″. for the inclination of the planes, and taken out of 90 d. leaveth 48 d. 11″. 23′. for the reclination of a b d, a c e and c b f, the 3 supe-



superiour planes, collaterall to the horizontall. Now by helpe of the former arch and angle, you may also find the reclination of the other six superiour planes, *by the second of the first case of R. S. triangles,* which will more plainly appeare by drawing the severall Scheme, (like unto this) proper to each plane, wherein Z F is given the arch of the Meridian betweene the Zenith and the Plane as afore, and Z F G the complement thereof the angle betweene the Meridian and the Plane, and the right angle at G: to find the side Z G the reclination desired, *by the second of the first Case of R. S. triangles.* For

				Logar.
As the sine of Z G F	90 *d.*	0′	0″.	10000.0000
Is to the sine of Z F	20	54	18½	9552.4511
So is the sine of Z F G	69	5	41½	9970.4228
To the sine of Z G	19	28	16	~~1~~9522.8739

Wherefore 19 *d*. 28′. 16″. is the reclination of the six superiour planes, which we sought for.

The declinations of these planes may from the same *data* be as easily found, whereof a c e, and b c f, two of the superiour planes decline 60 d. apiece, as is manifest, because the Horizontall lines of those two planes a c, and b c, doe decline from the line a b representing the Azimuth of e and W, untill they make an equilateral triangle, a b c which is equiangled *by the 28 of the first of Pitiscus,* and each angle containing 60 d, *by the 53 of the same,* the declination of the two Meridionall planes g c f, and g e c may be found in the Diagram aforesaid, *by the first of the 13 Case of R. S. Triangles.*

			Logar.
As the whole sine B G	90. *d.*	0′. 0″.	10000.0000
Is to the tang. of the reclination Z G	19	28. 16.	9548.4523
So is F S the cotangent of F Z	20	54 18½	10417.9788
To S B the cosine of the declinatiō S C	22	14. 19.	~~1~~9966.4311

Now as the declination of these two planes is found by this particular Diagram, so may the rest by drawing several Schemes proper to them, but they may be more easily drawne out the figure representing the body, by way of discourse onely, without further solution of any triangle at all; for if you suppose straight lines to be drawn within the body of the *Icosahedrum*, from the three

three angles of the three ſuperiour reclining planes, they will make an equilateral triangle, as is f d e, & the angles of each paire of planes interjacent, to wit g f c, & g e c, b f k and b d k, a e h, & a d h, will be but 30 d. apiece in this plane ſuperficies, which are 60 d. in the ſolid body, the ſides alſo g c, k b, and h a, ſubtending thoſe angles, will fore ſhorten proportionally, for ſeeing d g the ſide of the triangle d f g, is the diameter of the circle, including al the outward angles, *by the 53 of the 1 of Pitiſcus*: the angle d f g ſhall be a right angle, but c f b is 60 d. one of the angles of an equilater triangle, therefore g c f 30 d. the complement to 90 d. which was deſired. Now if you make f c the radius, c g ſhall be the tangent of 30 d. and the naturall tangent of 22 d. 14′. 19″, 40888. taken of the ſector (opened to the widcth of c f) ſhall give the pricks at r o, and V, to which ſtraight lines being drawn round about the body, *viz.* from the angle f, f r, and f o: from the angle d, d o and d v: and from the angle e, e r and e v, they ſhall repreſent the horizontall lines of each ſeverall plane, as f e, b a, & o v doe the line or azimuth of E. and W, the difference betweene which two lines is the declination deſired: for if the horizontall line f r, or e r, be ſuppoſed to lie upon the line e f, where it hath no declination at all, and to move upon the centers e or f, into the true poſition at r, then ſhall r f c, or r e t be an angle of 22 d. 14′. 19″. the declination of the two Meridian planes deſired: ſo if the horizontall line f o or e v lie upon the line e f, and from thence move upon the centers f and e to their due places, at o and v, c f o and c e r ſhall be an angle of 82 d. 14′. 19″. *viz.* c b f or c e a 60 d. and b f o, or a e r 22. d. 14′. 19″. the declination of the two intermediate planes deſired. Laſtly, if the horizontall line o d or v d be ſuppoſed to lie upon the verticall o v, and from thence to move upon the centers o and v, into their due places at d, m o d and m r d ſhall be an angle of 37 d. 45′. 41″. the complements of m d o, or m d r, 52 d. 14′. 19″. compoſed of the two triangles m d b 30 d. and d b o, 22 d. 14′. 19″. and therefore the declination of the two Septentrionall planes deſired. Theſe things thus prepared, the North reclining Diall 48 d. 11′. 23″. is to be made like the ſecond kind of the 14 Chapter, whoſe houre diſtances from the Meridian are as followeth.

Houres

Houres and parts from the Merid.	Houre arches on the plane.	Houres and parts from the Merid.	Houre arches on the plane.	Houres and parts from the Merid.	Houre arches on the plane.
Houres.	d '	*Houres.*	d '	*Houres.*	d "
12 0		10 2	29 57	8 4	59 57
. ½	7 29	. ½	37 27	. ½	67 28
11 1	14 59	9 3	44 57	7 5	74 59
. ½	22 28	. ½	52 27	. ½	82 29

d b a North reclining	48 d.	11'.	23".
adde thereunto	38	28	0
The heighth of the stile	86	39	23
The Logar.	9999.	2600.	

The other two South reclining as much, and declining also 60 d. *viz.* b c f and a c e have the same Diall, serving for both, changing the position of the substile and houres, as is afore directed, and are to be made by the rules of the 17 Chapter, the particulars whereof with the houre distances from the substile, are as followeth.

Houres from the substile.	Houre arches on the plane.	Houres from the Substile.	Houre arches on the plane.
Houres.	d '	*Houres.*	d '
½	0 24	9 . 3	2 26
10 . 2	3 14	½	5 20
½	6 11	8 . 4	8 25
11 . 1	9 19	½	11 45
½	12 46	7 . 5	15 32
12 12	16 42	½	19 56
½	21 19	6 . 6	25 17
1 . 11	27 0	½	32 0
½	34 13	5 . 7	40 48
2 . 10	43 45	½	52 36
½	56 34	4 . 8	68 13
3 . 9	73 16	½	87 12

b c f and a c e South reclining 48 d. 11'. 23".
Declining East and West 60 . 0 . 0.

1 The arch of the plane betwixt the Meridian and the Horizon 87 d. 45'. 41".
2 The arch of the Meridian betwixt the plane and the Zenith 65 54 19
3 The heighth of the stile or pole above the plane 22 6 03
4 The distance of the Substile from the Meridian 16 41 13
5 The angle betweene the two Meridians 38 32 50

The two South reclining 19 d. 28'. 16". *viz.* g e f and g c e doe also decline 24 d. 14'. 19". and are to be made by the rules of the 16 Chapter, the particulars whereof are as followeth.

Houres from the Substile.		Houre arches on the plane.		Houres from the Substile.		Houre arches on the plane.	
Houres.		d	'	*Houres.*		d	'
11 .	1	1	56	½		0	11
½		4	7	10 .	2	2	19
12 .	12	6	27	½		4	32
½		9	0	9 .	3	6	53
1 .	11	11	55	½		9	29
½		15	24	8 .	4	12	30
2 .	10	19	44	½		16	6
½		25	26	7 .	5	20	37
3 .	9	33	22	½		26	38
½		45	9	6 .	6	35	8
4 .	8	63	1	½		47	49
½		87	38	5 .	7	66	58

g f c and g e c South reclining 19 d. 28'. 16".
Declining East and West 22 14 19

1 The

1	The arch of the plane betwixt the Meridian and Horizon.	82 d.	14′.	19″.
2	The arch of the Meridian betwixt the Plane and the Zenith.	20	54	18
3	The heighth of the Stile or Pole above the Plane.	16.	22	19
4	The distance of the Substile from the Meridian	6	26	34
5	The angle betweene the two Meridians	21	49	56

The two middle Planes North reclining as much f k b, and e h a, doe also decline 82 d. 14′. 19″. and are so to be made by the rule of the 20 Chapter, the particulars whereof are as followeth.

Houres from the Substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	′	*Houres.*	d	′
½	0	19	6. 6	2	15
5. 7	2	53	½	4	53
½	5	33	7. 5	7	40
4. 8	8	23	½	10	43
½	11	31	8. 4	14	10
3. 9	15	6	½	18	14
½	19	21	9. 3	23	13
2. 10	24	38	½	29	35
½	31	38	10. 2	38	8
1. 11	40	42	½	50	1
½	53	37	11. 1	66	26
12. 12	71	17	½	87	17

k f b and a e h	*North reclining*	19 d.	28′.	16″.
	Declining East and West	82	14	19

1 The

1	The arch of the Plane betwixt the Meridian and Horizon	22 d.	14′.	19″.
2	The arch of the Merid: betwixt the Plane and the Zenith	69	5	41.
3	The heighth of the Stile or Pole above the Plane	19	53	19.
4	The distance of the Substile from the Merid:	71	17	90.
5	The angle betweene the two Meridians	83	25	34.

The other two North reclining as much *viz.* k b d and h a d doe also decline 37 d.45′.41″. and are to be made by the rules of the 19 Chapter, the particulars whereof with the houre distances from the Substile are as followeth.

Houres from the Substile.			Houre arches on the plane.		Houres from the Substile.			Houre arches on the plane.	
Houres.			d	′	*Houres.*			d	″
	½		3	12	8		4	2	14
9		3	8	41		½		7	43
	½		14	19	7		5	13	19
10		2	20	12		½		19	9
	½		26	24	6		6	25	17
11		1	33	2		½		31	50
	½		40	13	5		7	38	55
12		12	48	2		½		46	37
	½		56	32	4		8	55	0
1		11	65	44		½		64	4
	½		75	32	3		9	73	46
2		10	85	44		½		83	55

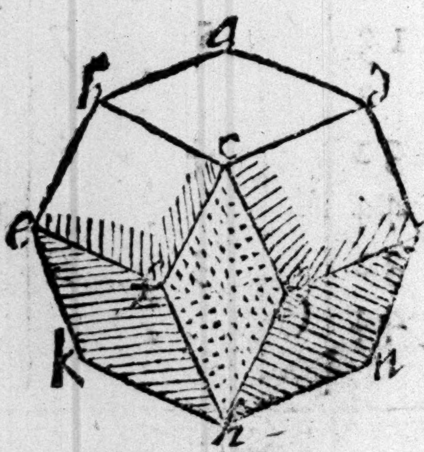
kdb *and* hda	*North reclining*	19*d.*	28′.	16″.
Declining East and West		37	45	41.

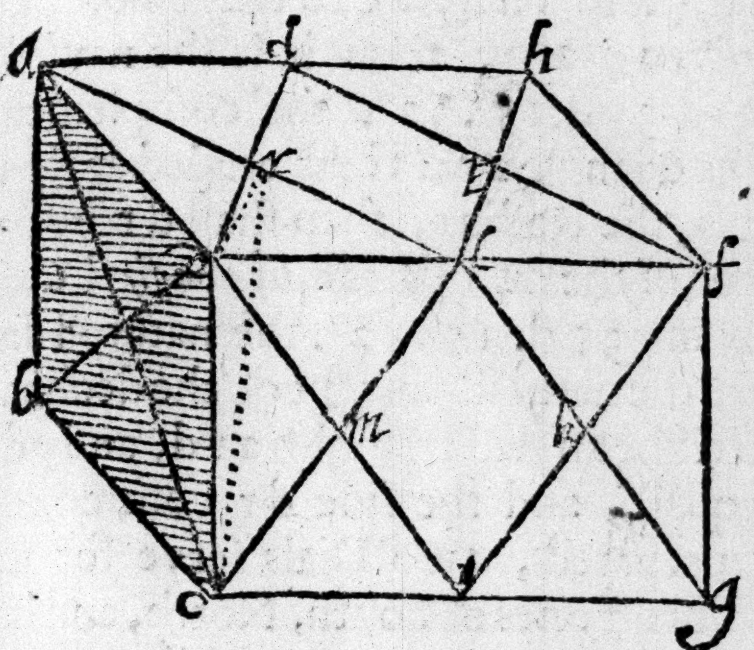
1	The arch of the Plane betwixt the Meridian and the Horizon.	75d.	31′.	21″.
2	The arch of the Meridian betwixt the Plane and the Zenith	24	5	41
3	The heighth of the stile or pole above the plane	46	26.	21
4	The distance of the Substile from the Meridian	48	2	4
5	The angle betweene the two Meridians.	56	54.	32

Chap. XXIV.

How to cut the bodie made of 12 Rhombes.

A *Rhombe* is defined by *Euclide* 31 *Definition of the first Booke* to be an oblique Paralellogram consisting of foure equall sides, but unequall angles, as is the figure a b c d; of this plane may be composed two bodies, the one of 12 *Rhombes* as is the figure a e h; the other of 30. To cut the body of 12 *Rhombes*, you must make a paralellepiped, as is a b g f. Let the length be to the breadth, or depth, as 1 to the root of $\frac{1}{2}$, so shal a h or c g be 100000 the bredth and depth a d f g equall 7071. Divide the length into two equall parts at n, l, 1 from these points draw lines





lines to the angles, and they shal include foure *Rhombes*, as are m i k l, and l p n r, &c. Draw upon each end two Diagonall lines, a c & b d, which joyning at each angle, with the lines drawne from the middle points, shall make up eight Triangles, such as is a l c, &c. cut away each corner by these triangles, *viz.* d by the triangle a l c, and f by the Triangle g l h, and so of the rest, so shall you at eight sections frame the body of 12 *Rhombes*, such as in the example appeareth.

The body being thus prepared, set the acute angle C of the horizontall *Rhombe* a b c d South, then will f h g c be a direct South, and his opposite a direct North Diall; the other are all declining alike, whereof the foure uppermost doe decline 30 d. and their opposites incline as much, as may be proved by the paralellepiped, whereon they are made; from any angle whereof as from d draw the perpendicular d r, crossing the line a l at right ang les in r, then shall d r be the naturall tangent of the angle d c r the reclination desired; but for the more easie finding thereof, first seeke the declination of the said *Rhombe*. Suppose the side d f g c of the paralellepiped stand South, and the line l r, which is the horizontall side of the *Rhombe* c b e f, to lie upon the line d l f, representing the prime verticall, then doth it not decline at all, but moving it upon the center l, till it returne into its due position, it shall decline from d l the quantity of the angle d l a, and so much doth the line n d on the back part thereof decline from the side n a paralell to l d; wherfore in the right angled Triangles a d l, or d a n, if you make a n or l d the root of 1 to be the radius, then shall a d the root of 2. 1414³ be the naturall tangent of the angle a n d, or a l d, which gives 54.d.44′.8″. the declination desired, as in the table of naturall tangents doth appeare.

Or againe, if you take a d (with reference to the whole side d f, for radius) as it is first given 70710, then is it the naturall tangent of the lesser angle a f d 35 d. 15'. 52". the complement of the former. Lastly, in the triangle a r d right angled at r, if you make a d the Hypotenusa, the Radius, then shall d r be the sine of d a r, the complement of the declination, *by the first Case of R. S. triangles*, which being 35 d. 15'. 52". the naturall sine thereof is 57735 equall to d r the naturall tangent of the declination 30 d. because the two right angled triangles a r d, and c d r have the sides a d and c d equall, and the side d r common to both. These things being prepared, two Dials serve for the whole body (except the ordinary ones of South, North, and horizontall) which are to be made by the examples of the 17 and 19 Chapters, the particulers whereof with the houre distances from the Substile, are as followeth.

Houres from the Substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	'	*Houres.*	d	'
½	0	42	6 . 6	4	34
7 . 5	6	0	½	9	56
½	11	24	5 . 7	15	27
8 . 4	16	59	½	21	16
½	22	53	4 . 8	27	28
9 . 3	29	12	½	34	9
½	36	2	3 . 9	41	26
10 . 2	43	31	½	49	27
½	51	44	2 . 10	58	14
11 . 1	60	44	½	67	47
½	70	28	1 11	77	59
12 . 12	80	48	½	88	34

The planes adjacent to the sides of the horizontall b a, a d, are

North reclining	30 *d.*	0'.	0".
Declining East and West	54	44	8

The

1 The arch of the plane betwixt the Meridian and Horizon.	54 d.	44'.	8''.
2 The arch of the Meridian betwixt the Plane and the Zenith.	45	0	0
3 The heighth of the Stile or Pole above the Plane.	44	37	44
4 The distance of the Substile from the Meridian	80	47	51
5 The angle betweene the two Meridians	83	30	24

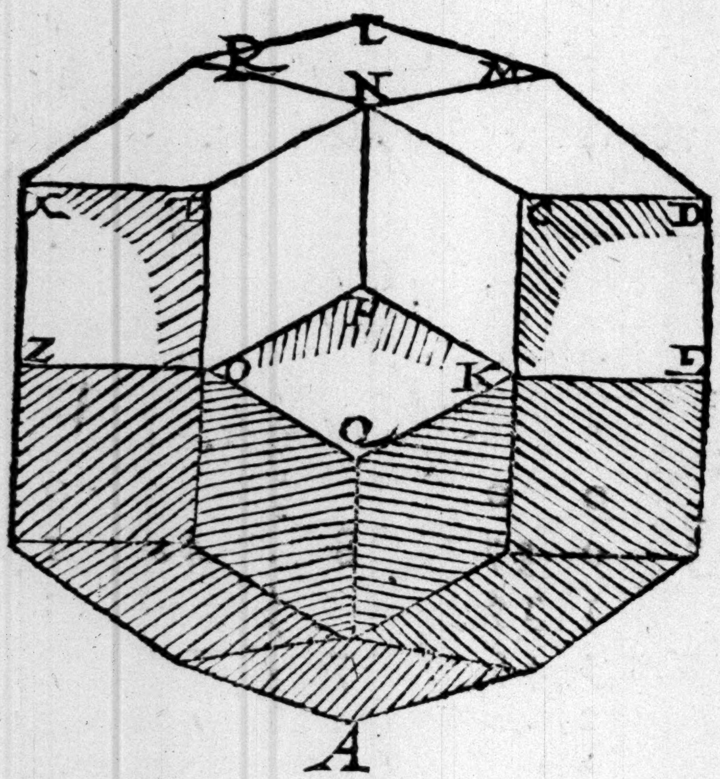
Houres from the Substile.			Houre arches on the plane.		Houres from the Substile.			Houre arches on the plane.	
Houres.			d	'	*Houres.*			d	
	½		0	0		½		0	36
9	.	3	0	37	8	.	4	1	13
	½		1	15		½		1	53
10	.	2	1	55	7	.	5	2	38
	½		2	40		½		3	30
11	.	1	3	33	6	.	6	4	34
	½		4	38		½		5	57
12	.	12	6	1	5	.	7	7	52
	½		8	0		½		10	54
1	.	11	11	5	4	.	8	16	31
	½		16	55		½		30	49
2	.	10	32	4	3	.	9	87	43

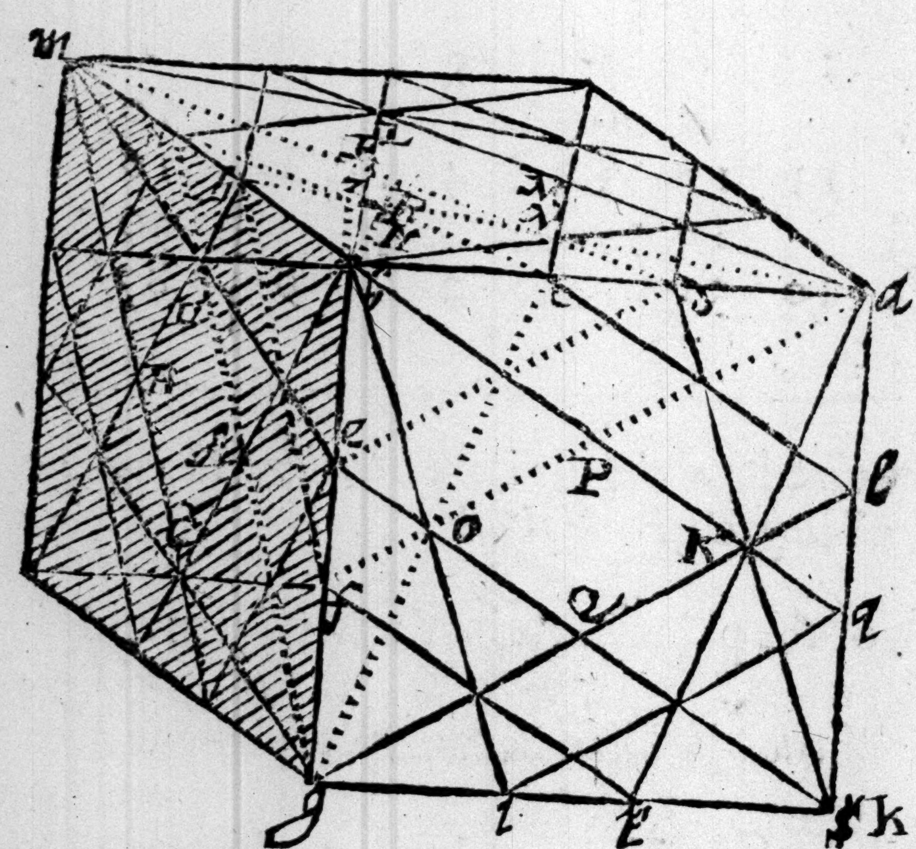
The Planes b c f e *and* d c g i, *are South reclining* 30 d. 0'. 0''.
Declining East and West 54. 44. 8

1 The arch of the plane betwixt the Meridian and the Horizon	54	44	8
2 The arch of the Meridian betwixt the plane and the Zenith	45	0	0
3 The heighth of the stile or pole above the plane	44	36	53
4 The distance of the Substile from the Meridian	4	37	48
5 The angle betweene the two Meridians	45	11	9

S 3 *To*

To cut the body composed of 30 *Rhombes.*





This body of 30 *Rhombes*, represented by the figure L Z A E, is somewhat more troublesome to cut then the former, and is fra-

framed out of the *Cube* adjoyning a m g k, dividing every side thereof by extreme and meane proportion, which is thus easily done. Let a b, b g, b m &c. be 10000, then shall a c, b d, b n, m h, b f, g e, &c. be 6180 the greater segments, which taken of the sector, opened to the widest of any side, and set from each angle a.b.g.m, &c. both wayes, shall leave a d, b c, b h, m n, b e, g f, &c. 3819 the lesser segments of the same sides; from the termes of the greater segments on the one side, to the lesser on the other side, draw paralell lines, as are d e, a f, l g, and q i; crosse them with the like paralell lines, as are c l, b q, e k, and f p; from each opposite angle b k, and a g, unto the lesser segments, opposite to the said angle, draw paralell lines as are a p, g c, b i, and k d, so have you all the lines on this side the Cube, necessary for direction in cutting this body; and thus must you doe with all the rest of the sides.

The lines being drawne as you see in the example, there are three triangles framed about every solid angle, as are the prickt lines a f h, m d e, and g n c, about the angle b, by which that angle must be three times cut, (continuing each line as part is cut away to auoid confusion) so shall you at 24 cuts, produce the body of 30 *Rhombes* the thing desired; which being prepared, set the acute angle N of the horizontall *Rhombe* thereof N M L R South, then shall the *Rhombe* O P Q K be South also, and his opposite North A B C D of the Cube (being the same in the body) West, and his opposite East, the rest are all South and North declining reclining; and as the three Rhombes O P N T, T N R X, and T X Z O, which are conterminous with the horizontall South and West planes, doe decline and recline, so doe all the rest, as from the very inspection of the body doth sufficiently appeare; wherefore having found the declination and reclination for those three planes, there is as much done as is needfull for this body.

And first for the declination of the Rhombe O P N T, whose side O P is the same with the South Rhombe O P Q K, in the triangle a f h of the Cube (which is one of the cuts of the solid angle b) producing the Rhombe aforesaid, if you suppose the line a h to lie upon the side of the Cube a b, standing South, it shall

re-

represent the prime verticall, wherein the South plane lyeth, and hath no declination at all: but moving it upon the center a from b to h, the quantity of the lesser segment $3^{\underline{8106}}$, and making a b the Radius, b h shall be the naturall tangent of the angle b a h, which being found in the table of the naturall tangents, shall give the arch 20 d. 54′. 18″ $\frac{1}{2}$. the declination of the Rhombe desired.

Now if you draw the perpendicular b Z from the angle b to the line of declination a h, b Z shal be the naturall tangent of the inner angle b f Z (making f b the radius) the reclination of the Rhombe desired, which is thus found *by the first Case of R. P. Triangles.*

		Logar.
As the sine of b Z h	90 *d.* 0′.	10000.00
Is to the line b h	$3^{\underline{819}}$	0581.95
So is the cosine of the declination b h z	20 *d.* 54′. 18″.	9970.43
To the line b Z	$3^{\underline{568}}$	10552.38

And againe in the triangle b f Z, *by the seventh Case of R. P. Triangles.*

	parts.	Logar.
As the greater segment f b	$6^{\underline{180}}$	0790.99
Is to the line f b *as radius*		10000.00
So is the line b Z	$3^{\underline{568}}$	0552.42
To the same line as tangent of the angle b f Z	30 *d.* 0	9761.43

The reclination desired.

Againe, in the triangle d m e, by which the Rhombe T N R X, adjacent to the horizontall is cut, if you suppose the side thereof d m to lie upon the prime verticall d b, then hath it no declination, but being moved upon the center d, till it returne into its due situation at m, then shall d b be the radius, and b m the side of the cube shall be the tangent of the angle b d m, the declination of the plane, *by the aforesaid seventh Case of R. P. Triangles.*

		Logar.
As the greater ſegment db	6180	0790.99
Is to the ſame line db *as radius*		10000.00
So is the ſide of the cube bm	10000	1000.00
To the ſame line b m *as tangent of the angle* b d m	58.*d*.16′.57″.	10209.01

Or againe, if you make the ſide of the *cube* mb the radius, bd the greater ſegment ſhall be the naturall tangent of bmd 31 d. 43′. 3″. the complement of the declination ſought for.

Now draw the perpendicular bf to the line of declination dm, then ſhall bF be the naturall tangent of the inner angle of reclination beF, making be the Radius, which is thus found in the triangle bFd, right angled at F, *by the firſt Caſe of R.P. Triangles.*

			Logar.
As bFd *the ſine of*	90 d.	0′	10000.00
Is to the ſide bd	6180		0790.99
So is the ſine of bdF	58 *d.*	16′. 57″.	9929.75
To the ſide bF	5257		10720.74

And againe, in the triangle beF, *by the ſeventh Caſe of R.P. Triangles.*

		Logar.
As the leſſer ſegment be	3819	0581.95
Is to the ſame line as radius		10000.00
So is the line bF	5257	0720.74
To the ſame line as tangent of the angle beF *the reclination deſired.*	54 *d*.0.	10138.79

Laſtly, in the triangle gnc, by which the Rhombe ZXTO adjoyning to the Weſt plane is cut, if you ſuppoſe the ſide thereof cn to lie upon the prime verticall cb, and to be moved upon the center C into its due poſition at n, then ſhall cn be paralell to dm, and ſo the ſides and angles of the two triangles dbm, and cbn, proportionall each to other, and conſequently the declination of both planes the ſame, which may be found *by the ſeventh Caſe of R.P. triangles.* For

		Logar.
As cb *the lesser segment*	3819	0581. 95.
Is to cb *as radius*		10000. 00.
So is bn *the greater segment*	6180	0790. 99.
To bn *as tangent of the angle* bcn	58. 16'. 57''.	10209. 04.

The declination of the Rhombe desired: Or if you will make nb the radius, and suppose the line of declination ng to lie in the Meridian nb, and from thence to move upon the center n into its due situation, then shall bg the side of the Cube, become the naturall tangent of the angle bng, yeelding the same as afore; because nb is meane proportionall betweene bg and bc. Vnto either of these lines of declination ng, or nc draw a perpendicular from b, as is bH, which will fall upon the line bF, because dm, & cm are paralels; then shall bH be the naturall tangent of the inner angle bgH, making bg the Radius, the reclination of the said Rhombe: which is thus found. In the triangle bHc, right angled at H, *by the first case of R.P. triangles.*

				Logar.
As bHc, *the sine of*	90 *d.*	0'.	0''.	10000.00
Is to the line bc *the lesser segment*	3819			0581.95
So is bcH *the sine of the declinatiõ*	58 *d.*	16'.	57''.	9929.75
To the line bH	3249			10511.70

And againe, *by the 7 Case of R.P. Triangles.*

		Logar.
As the line gb	10000	1000.00
Is to the same line as radius		10000 00
So is the line bH	3249	-0511.70
To the same line as tangent of the angle bgH *the reclination desired,*	18 *d.* 0.	9511.70

These things being prepared, six Dials (besides the ordinary ones) proper to the six planes lying betweene the horizontall, South,

South, North, and West or East planes, serve for the whole body, whereof three are South declining reclining, and three North declining reclining alike; the first for the plane OPST, is to be made by the example of the 16 Chapter being a South declining West, 20 d. 54'.18''. reclining 30 d. 0'. the particulars whereof, with the houre distances from the Substile, are as followeth.

Houres from the substile.			Houre arches on the plane.		Houres from the Substile.			Houre arches on the plane.	
Houres.			d	'	*Houres.*			d	'
11	.	1	0	21		½		0	20
	½		1	12	10	.	2	1	21
12		12	2	6		½		2	15
	½		3	4	9	.	3	3	15
1	.	11	4	10		½		4	22
	½		5	28	8	.	4	5	43
2	.	10	7	6		½		7	26
	½		9	17	7	.	5	9	43
3	.	9	12	26		½		13	7
	½		17	37	6	.	6	18	52
4	.	8	27	59		½		30	48
	½		55	23	5	.	7	64	2

OPNT and KPNC South reclining 30 d. 0'. 0''.
Declining East and West 20 54. 18

1 The arch of the plane betwixt the Meridian and Horizon.	79 d.	11'.	16''.
2 The arch of the Meridian betwixt the Plane and the Zenith.	31	43	3
3 The heighth of the Stile or Pole aboue the plane	6	25	3
4 The distance of the Substile from the Meridian	12	5	40
5 The angle betweene the two Meridians.	18	7	5

The

The South declining West T N R X 58 d. 16′. 57″. doth also recline 54 d. and is to be made by the example of the 17 Chapter, the particulars whereof with the houre distances from the Substile, are as followeth.

Houres from the substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	′	*Houres.*	d	′
10 . 2	1	42	½	1	36
½	5	4	9 . 3	4	58
11 . 1	8	34	½	8	28
½	12	20	8 . 4	12	13
12 12	16	30	½	16	22
½	21	14	7 . 5	21	4
1 . 11	26	48	½	26	38
½	33	33	6 . 6	33	19
2 . 10	41	58	½	41	42
½	52	37	5 . 7	52	14
3 . 9	65	58	½	65	32
½	81	48	4 . 8	81	17

T N R X, and C N M D, South reclining	54 d.	0′.	0″.
Declining East and West	58	16	57

1 The arch of the plane betwixt the Meridian and Horizon.	37 d.	22′.	38
2 The arch of the Meridian betwixt the Plane and the Zenith.	69	5	42
3 The heighth of the Stile or Pole aboue the plane	26	10	52
4 The distance of the Substile from the Meridian	16	29	25
5 The angle betweene the two Meridians.	33	51	33

The

The South declining West OTXZ, 58 d. 16′. 57″. doth also recline 18 d. and is to be made by the example of the 16 Chapter, the particulars whereof, with the houre distances from the Substile, are as followeth.

Houres from the Substile.		Houre arches on the plane.		Houres from the Substile.		Houre arches on the plane.	
Houres		d	′	*Houres*		d	′
½		0	7	8	4	0	24
9	3	0	38	½		0	56
½		1	11	7	5	1	30
10	2	1	47	½		2	8
½		2	27	6	6	2	52
11	1	3	13	½		3	44
½		4	12	5	7	4	51
12	12	5	28	½		6	23
½		7	19	4	8	8	44
1	11	10	18	½		12	58
½		16	17	3	9	23	7
2	10	34	11	½		66	54

OTXZ, and KCDE, South reclining 18 *d.* 0′. 0″.
Declining East and West 68 16 57.
58

1 The arch of the Plane betwixt the Meridian and the Horizon. 63 d. 26′. 6″.
2 The arch of the Meridian betwixt the Plane and the Zenith 31 43 3
3 The heighth of the stile or pole above the plane 3 57. 40
4 The distance of the Substile from the Meridian 5 28 8
5 The angle betweene the two Meridians. 54 11. 33

The

The North declining West 20d. 54′. 18″. adjacent to the North Rhombe, doth also recline 30 d. 0′. 0″. and is to be made by the example of the 19. Chapter, the particulars whereof with the houre distances from the Substile, are as followeth.

Houres from the Substile.	Houre arches on the plane.		Houres from the Substile.	Houre arches on the plane.	
Houres.	d	′	*Houres.*	d	′
½	5	37	9 . 3	1	5
10 . 2	12	23	½	7	49
½	19	13	8 . 4	14	35
11 . 1	26	11	½	21	28
½	33	18	7 . 5	28	29
12 . 12	40	37	½	35	39
½	48	8	6 . 6	43	2
1 . 11	55	53	½	50	38
½	63	51	5 . 7	58	27
2 . 10	72	0	½	66	28
½	80	17	4 . 8	74	40
4 . 10	88	38	½	82	59
3 9					

North reclining	30 *d.*	
Declining East and West	20 *d.*	54′. 18″.

1 The arch of the plane betwixt the Meridian and the Horizon — 79 d. 11′. 16″.
2 The arch of the Meridian betwixt the plane and the Zenith — 31 43 3
3 The heighth of the stile or pole above the plane — 63 28 31
4 The distance of the Substile from the Meridian — 40 36 56
5 The angle betweene the two Meridians — 43 47 6

The North declining West 58 d. 16′. 57″. adjacent to the horizontall, doth also recline 54 d. and is to be made by the ex-

example of the 20 Chapter, the particulars whereof, with the houre distances from the Substile are as followeth.

Houres from the Substile.		Houre arches on the plane.		Houres from the Substile.		Houre arches on the plane.	
Houres.		d	'	*Houres.*		d	'
8 .	4	1	59	½		5	17
½		8	12	7 .	5	10	27
9 .	3	14	31	½		16	48
½		20	59	6 .	6	23	20
10 .	2	27	46	½		30	07
½		34	38	5 .	7	37	12
11 .	1	41	56	½		44	38
½		49	36	4 .	8	52	27
12 .	12	57	40	½		60	36
½		66	6	3 .	9	69	13
1 .	11	74	52	½		78	3
½		83	51	2 .	10	87	5

North reclining	54 *d.*
Declining East and West	58 *d.* 16'. 57''.

1	The arch of the plane betwixt the Meridian and Horizon.	37 d.	22'.	39''.
2	The arch of the Meridian betwixt the Plane and the Zenith.	69	5	41
3	The heighth of the Stile or Pole above the Plane.	55	39	21
4	The distance of the Substile from the Meridian	57	40	4
5	The angle betweene the two Meridians	62	24	28

The North declining West 58 d. 16'. 57''. adjacent to the West Rhombe doth also recline 18 d. and is to be made by the ex-

example of the 19 Chapter, the particulars whereof, with the houre distances from the Substile, are as followeth.

Houres from the Substile.		Houre arches on the plane.		Houres from the Substile.		Houre arches on the plane.	
Houres.		d	'	*Houres.*		d	'
7	5	0	39	½		3	31
½		4	49	6	6	7	45
8	4	9	6	½		12	11
½		13	37	5	7	16	56
9	3	18	30	½		22	8
½		23	52	4	8	27	58
10	2	29	56	½		34	39
½		36	56	3	9	42	26
11	1	45	8	½		51	36
½		54	46	2	10	62	20
12	12	66	59	½		74	36
½		78	29	1	11	87	54

North reclining 18 *d.*
Declining East and West 58 *d.* 16'. 57''.

1	The arch of the Plane betwixt the Meridian and Horizon.	63 d.	26'.	6''.
2	The arch of the Meridian betwixt the Plane and the Zenith.	31	43	3.
3	The heighth of the Stile or Pole above the Plane	33	34	18
4	The distance of the Substile from the Merid:	65	59	31
5	The angle betweene the two Meridians	76	11	40

CHAP.

CHAP. XXV.

How to describe the Paralels of the Signes and diurnall arches upon any of the aforesaid Planes.

MAny Astronomicall conclusions may bee described upon every sort of Plane, amongst them, I have made choice of six, *viz.*

First, the paralels of the signes, shewing what part of the Zodiacke, the Sun is in at all times of the yeare.

Secondly, the diurnall arches shewing the length of the day and night throughout the yeere.

Thirdly, the azimuths or verticall circles, shewing what quarter of the World, or what point of the Compasse, the Sun is in at any time of the day.

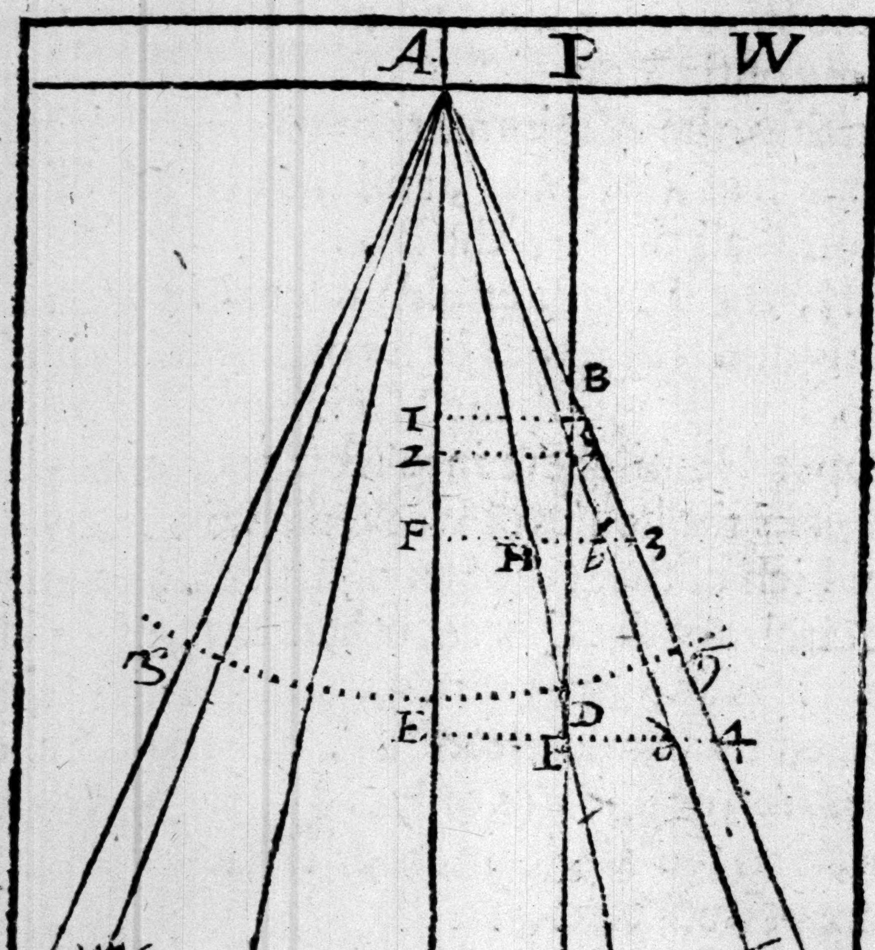
Fourthly, the Almicanters or circles of altitude, shewing the proportion of shadowes, and the heighth of the Sun above the Horizon at all times of the day.

Fiftly, the Iewish or old unequall houres.

Sixtly and lastly, the circles of position, chiefly those of 30 d. and 60 d. which with the Meridian and Horizon distinguishing the upper Hemisphere into six parts, commonly called by Astrologians the houses of Heaven, will shew at all times of the day, which of them the Sun possesseth. Amongst these some are great circles of the Sphere, others are small; the great circles in all sorts of planes, are represented by straight lines, the smaller are described by Conick sections: and they are either *Parabolas*, *Hyperbolas*, or *Ellipses*, only the signes and diurnall arches in the polar, and the almicanters or circles of altitude in the horizontall, are perfect circles.

Polar.

Now there are three various descriptions of these paralels, according as the planes (on which they are projected) do cut the axis of the World, rightly obliquely; or are paralell there to, I will begin with the easiest, which is the polar plane, in which the axis being cut at right angles, the houre lines doe meet with equall angles in the centre, representing the pole of the World, and the paralels described upon the pole, must therefore of necessity (agreeable to the Globe) be perfect circles, least about the center, and greatest neere the periphery or limbe : the stile of this Diall may be any streight prime, or wyer, whose length in respect of the houre lines is arbitrary, but the apex or top thereof, giving shadow upon the circles of declination, will enforce a proportion between the length of the stile, and greatnesse of the plane,



as is sufficiently declared in the ninth Chapter aforesaid: wherefore first make the *Trigone* A ♑ ♋, let the middle line thereof A E ♈ represent the Epuinoctiall, the rest the declinations of the Signes ♉, ♊, ♋, ♓, ♒, ♑, and their opposites) set off by the helpe of the chord both wayes from E, the distance of 11 d. 31'. 20 d. 13'. and 23 d. 31. the arches of declination, and draw straight lines from A thorough those points. Let A P equall to C B, the length of the stile in the Diall of the 14 Chapter, drawne perpendicular to A E, be given in some knowne parts, suppose 37 hundred parts of an inch, from P draw P D paralell to A E crossing the signes in B C D; the semidiameters of those paralels are P B, P C, and P D, which I desire to know; In the triangles A P B, A P C, and A P D, the angle at P is a right angle, the angle at A are the complements, and the angles at B, C, and D, are the declinations themselves of ♋ ♊ and ♉ &c. wherefore *by the second Case of R. P. Triangles.*

		Logar.
As the sine of A D P *the declination of* 0 *d.* ♉	11. 31'.	9300.28
Is to P A *the length of the stile in parts*	37	0431.80
So is the sine of D A P, *the compllement of the declination*	78 29.	9991.17
To the line P D *the Semidiameter of the circle of declination, for* 0 *d. of* ♉.	181	0259.09

In like manner you may find P C to be one inch, and P B 85 hundred parts of an inch, wherefore take of a scale of inches, 85, 100 and 181. and at those lengths draw the circles in the Diall of the 14 Chapter ♉ A ♍, ♊ 60 ♌, ♋ 15 ♋, so have you the paralels of the Northerne signes for the upper face of this plane, unto which the Southerne paralels in the nether face are equall: and thus may you, if you thinke fit, put on all the declinations betweene ♉ and the center.

But if you will worke by naturall tangents, you need not the solution of any triangle, because P D is a tangent line to A P. Let A P equall to the stile be radius, supposed to be divided into 100 1000, or 10000. parts, then is P B 2268 P C 2715 and P D 4908

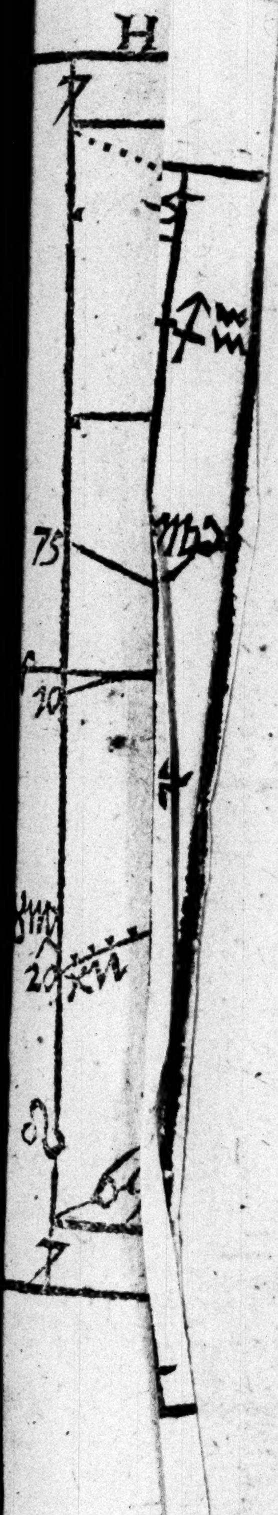
the naturall tangents of the complements of the declinations of ♋ ♊, and ♉ *by the ſecond caſe of R. P. triangles.* Wherefore dividing a line equall to the Radius A P *(as in the firſt Chapter)* or opening the Sector to the wideſt of A P, you may take of theſe tangents, which are the Semidiameters of the declinations, and with them draw the circles aforeſaid without any calculation at all.

CHAP. XXVI.

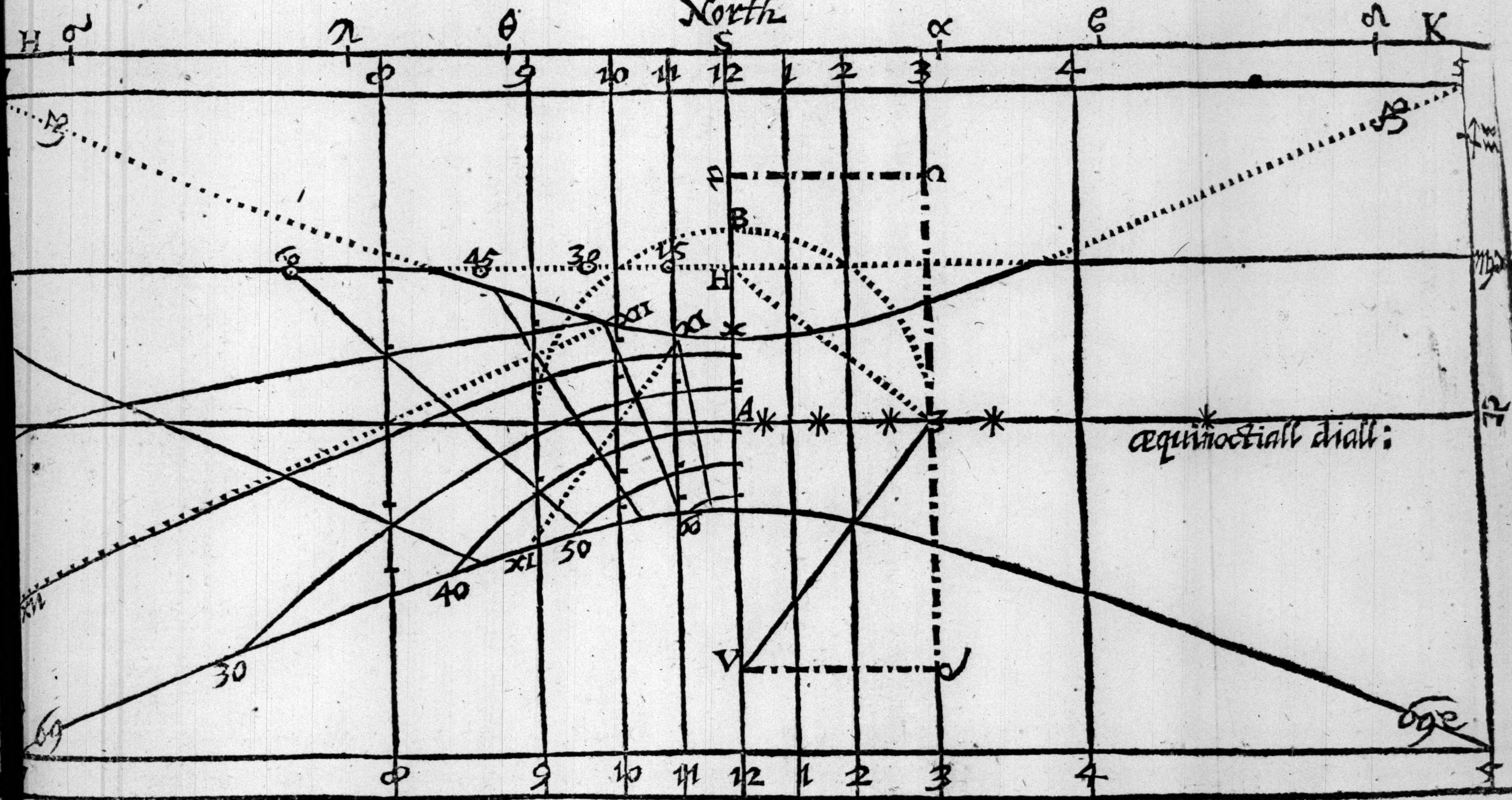
The ſecond ſort: Eaſt and Weſt Equinoctiall reclining, Equinoctiall reclining declining.

THe next ſort of planes are ſuch as cut the Æquator at right angles, and therefore are paralell to the axis, as are the Eaſt and Weſt direct, the Equinoctiall reclining, and declining reclining to the pole. In theſe the paralels of the ſignes and diurnall arches are thoſe Conicke Sections, which are called *Hyperbolas*, and may be as eaſily inſcribed as the former, yet herein alſo, becauſe the apex or top of the ſtile (or ſome Nodus equivalent in the paralell ſtile) doth ſhew the paralels drawn upon theſe kinds of Dials, we muſt of force proportion the ſtile to the plane (as is at large diſcourſed in the ninth Chapter.) Let A W in the Diagram aforeſaid be equall to A L, and A B, the length of the ſtiles, in the Dials of the ninth and thirteenth Chapters; which being made the Radius, ſet the diſtance from the top of the ſtiles at L and B, to the interſection of the houre lines and Æquator (which I call the ſecant of each houres diſtance) from 6 or 12 of clock, reſpectively, in the Dials of the aforeſaid Chapters downwards from A, in the line A E ♈ of this Scheme; ſo ſhall A F be the ſecant of 45 d. $1\underline{414}$. equall to L 9. and B 3. and ſo ſhall A E be the ſecant of 60 d. $2\underline{000}$ equall to L 8, and B 4 in the Dials aforeſaid

ſaid, &c. by which points F 3, and E 4 draw paralels to A P W or perpendiculars to A E ♈ , and they ſhall repreſent the houre lines of 9 and 3, and 8 and 4 in the Dials, croſſing the paralels of [illegible] in the Diagram, at the ſame di-



perpenc[illegible] [illegible]cenation , are tangent [illegible] to them , as F 3 to a F, and E 4 to A E, and



The line H S K *should be joyned to the former Scheme, as a Tangent line at* S.

Place this folio 269.

said, &c. by which points F 3, and E 4 draw paralels to A P W or perpendiculars to A E ♈, and they shall represent the houre lines of 9 and 3, and 8 and 4 in the Dials, crossing the paralels of the signes at H b 3, and c d 4 in the Diagram, at the same distances from F and E, that the houre lines doe in the Dials from the Equinoctiall lines thereof; which distances are thus easily found in the triangles A E c, A E d, and A E 4, the angle at E is a right angle, the angle at c d 4 are the complements and the angles at A the declinations themselves of ♉ ♊ ♋, and the side A E is the secant of 60 d. the houre of 4. of clock, which in the Tables you shall find to be 2000 the double of the Radius AW, wherefore *by the second Case of R. P. triangles.*

			Logar.
As the sine of the angle A c e	78 *d.*	29'.	0008.82. *Ar. compl.*
Is to the line A E	2000		0301.03.
So is the sine of the angle e A c	11	31	9300.27.
To the line e c *the distance of the paralell from the Æquator*	04	07	09610.12. *Compl. Charact.* 0.

In like manner you shall find the paralell of ♊ to be 736, and the paralell of ♋ to be 870 from the Æquator upon the foure of clock houre; wherefore if you open the Sector to the width of AW (or divide a line equall thereto) and take of either line the distances aforesaid, and set them both wayes upon the houres of 8 and 4 in the Dials, you have points in those houre lines, by which the paralels of the signes shall passe; doe the like with the rest of the houre lines in all respects.

But if you wil work by naturall tangents, you may with much more ease and speed performe the same: for making the secant of every houre from 6 or 12 of clocke respectively, to be a severall Radius (which is the distance betweene the top of the stile and intersection of each houre line upon the Æquator) perpendiculars crossing the paralelles of Declination, are tangent lines to them, as F 3 to a F, and E 4 to A E, and

consequently the distances are ready given in the Tables of naturall sines and tangents, without any calculation at all, which you may collect into a table in this manner; so making A F the radius, which is the secant of 45 d. for three of clock 1414, FH is the naturall tangent of 11 d. 31′ 204, and F b is the naturall tangent of 20 d. 13′, 368, and F 3 the naturall tangent of 23 d. 31′ 435; In like manner A E being the radius, which is the secant of 60 d. for 4 of clock 2000. E c, E d, and E 4, are the same tangents againe, onely the radius increased, and so of the rest of the houres; by helpe of the line divided equall to the radius, or by the sector, set these tangents both wayes from the Equinoctiall line of the Dials upon each correspondent houre line (as you see done in the example of the 13 Chapter) where they are prickt out (but not drawne to auoid confusion) so shall you have points, which drawne together into one continued circular line, shall give the paralels desired.

Houres.		*Equinoctiall distances.*		*Tangents.*	*Secants.*
12	6	d	′		
11 1	7 5	15	0	268	1045
10 2	8 4	30	0	577	1155
9 3	9 3	45	0	1000	1414
8 4	10 2	60	0	1732	2000
7 5	11 1	75	0	3732	3864

CHAP. XXVII.

The third ſort Horizontall South and North direct, declining, declining reclining.

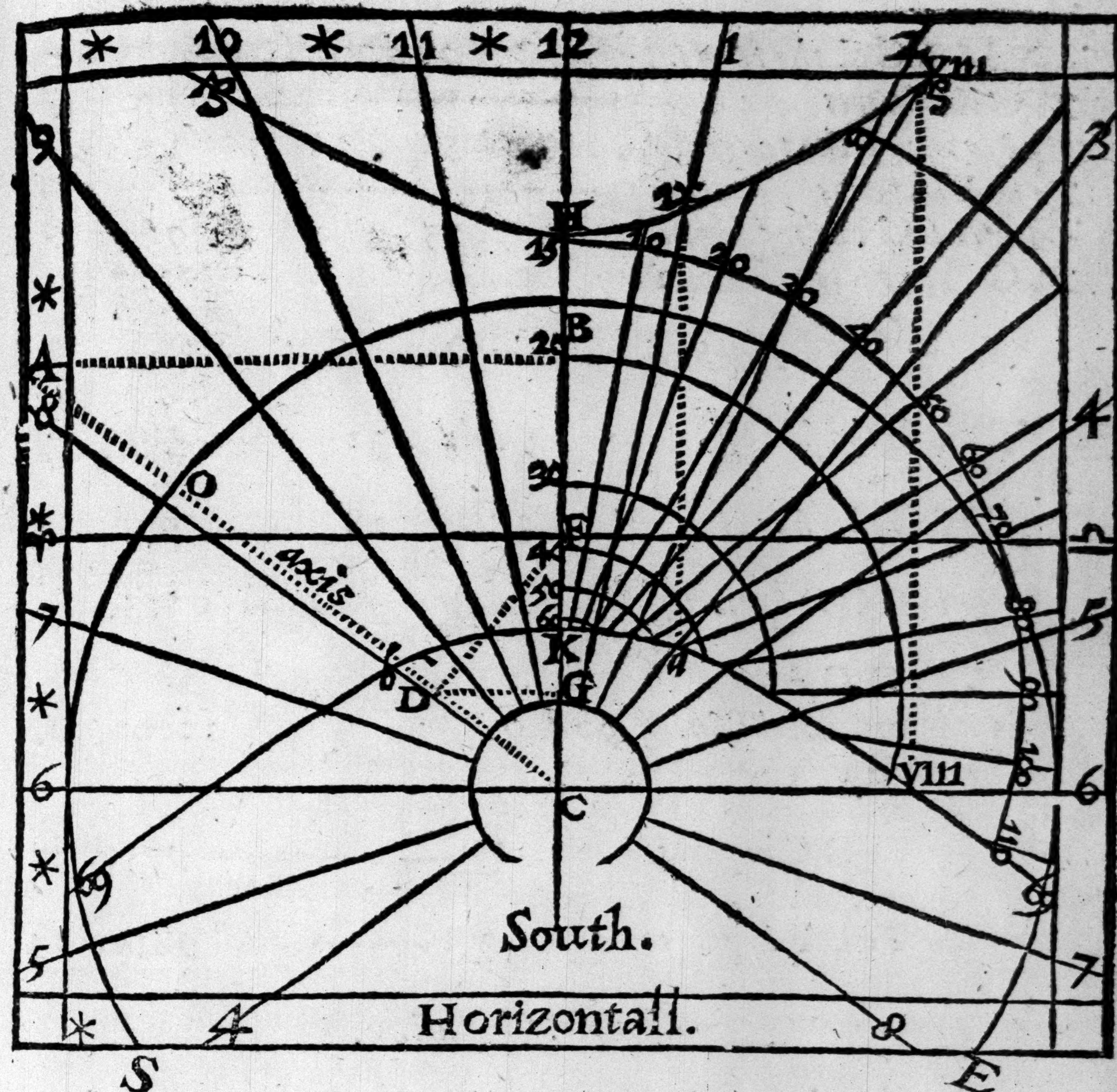
OF the third ſort are the reſt of the planes, which cutting the axis obliquely, have all the houre lines meeting in a center upon the axis with unequall angles, as in the Horizontall, South and North direct, declining, or declining reclining; in all which the paralels of the ſignes, and diurnall arches are conick ſections, but not alwayes the ſame. Now becauſe the top of the perpendicular ſtile, or ſome nodus equivalent in the trianguler ſtile, ſuppoſed to be in the center of the earth, doth give ſhadow to theſe paralels, (as in the former ſorts) it will be neceſſary to ſhew, how to proportion the perpendicular ſtile to the plane, or to find the place of the Nodus in a trianguler ſtile, there being no mention thereof needfull before, in projecting the houre lines upon any of theſe ſorts or planes; Firſt therefore aſſigne the place of the tropique, furtheſt diſtant from the center, moſt convenient for the plane, upon the 12 of clock houre or Meridian of the place, in all directs, but upon the Subſtile or Meridian of the plane in all the reſt. Let that be H in the horizontall for ♑, two inches diſtant from the center C, next ſeeke the Meridionall heighth of the Sun in each tropique upon the planes, which is alwayes thus found: The heighth of the pole or ſtile above the plane being given 51 d. 32′. the heighth of the Æquator is the complement thereof 38 d. 28′. unto which adde and ſubſtract 23 d′ 31. ſo have you 61 d. 59′. the heighth in ♋, and 14 d. 57′. the heighth in ♑. This done, ſuppoſe D G in the Dials of the ſixt and ſeventh Chapters to be the perpendicular ſtile, whoſe length I would know it is manifeſt *by the ſecond Caſe of R.P. triangles*, that if D G be radius $\overline{1000}$, C H is a tangent line thereunto, and G C is $\underline{794}$ the naturall tangent of 38 d. 28′. the complement of

the elevation, and G H is 3745 the naturall tangent of 75 d. 3′. the complement of the Meridionall heighth of the Sunne in ♑, which added together, give the whole line C H 4539 in parts of the Radius D G, wherefore divide the Radius 1000000 (increased with cyphers) by the number 4539, and the quotient will yeeld 220 (as in the 9 Chapter more at large) or without any other labour seek the Arithmeti: complement of the Log. of 45[illegible] in the *Chiliades*, which is 0343.03. & it shall give 2203, as aforesaid: This being found, divide a line equall to C H into 100 parts (as in the first Chapter) or open the Sector to the width of C H, and take of either 22 hundred parts, which is the length of the perpendicular stile D G, and must be the Radius for the rest of the worke: to which width againe a line divided, or the Sector opened, take of 794, the naturall tangent of 38 d. 28′. which set from C to G, shall give the place of the stile; from G to the axis C D draw a paralell to *6* C *6*, which shall be the perpendicular stile desired; from G to K set the naturall tangent of 28 d. 1′, 532, the cōplement of the Meridional heighth of the Sun in ♋, and K shall be the point for ♋. From G to F set the naturall tangents of 51 degrees, 32′, 1259 the heighth of the pole above the plane, and by F draw the straight line ♈ F ♎, paralell to the houre of *6*, for the Equinoctiall; From G to H set the naturall tangent of 75 degrees, 3′. 3745 the complement of the heighth of the Sunne in ♑, and it shall fall upon the point H formerly assigned. Lastly, C D is 1277 the secant of 38 degrees 28′. which giveth the place of the Nodus in the Trianguler stile, and D F is 1[illegible]0 the secant of 51 degrees 32′. If you like better to worke by a scale of inches, or for more certainty sake will joyne them together, then must you resolve many triangles to find these things, and first for the length of the stile.

	Logar.
As the tangents of C G *and* G H	4539 + 0656.96
Is to the line C H *in inches*	2000 + 0301.03
So is the Radius D G	+ 10000.00
To the line D G *in parts of an inch*	440 — 9644.07

Complement Charact. 0.

The



The length of the stile being found in parts of an inch, then *by the 2 Case of R. P. Triangles.*

		Logar.
As DG *the Radius*		+10000.00
Is to DG *in parts*	410	0355.93
So is GC *the tangent of*	38 d. 28′	+9900.09
To GC *in parts*	350	9544.16

Comple: charact. 0.

And

				Logar.
And so is G K *the tangent of*		28 *d.*	1'.	9725. 98
To G K *in parts*	234			9370.05.
And so is G F *the tangent of*		51	. 32	10099. 91
To G F *in parts*	554			9743.98.
And so is G H *the tangent of*		75	3	10573 46
To G H *in parts*	1650			0217.53.

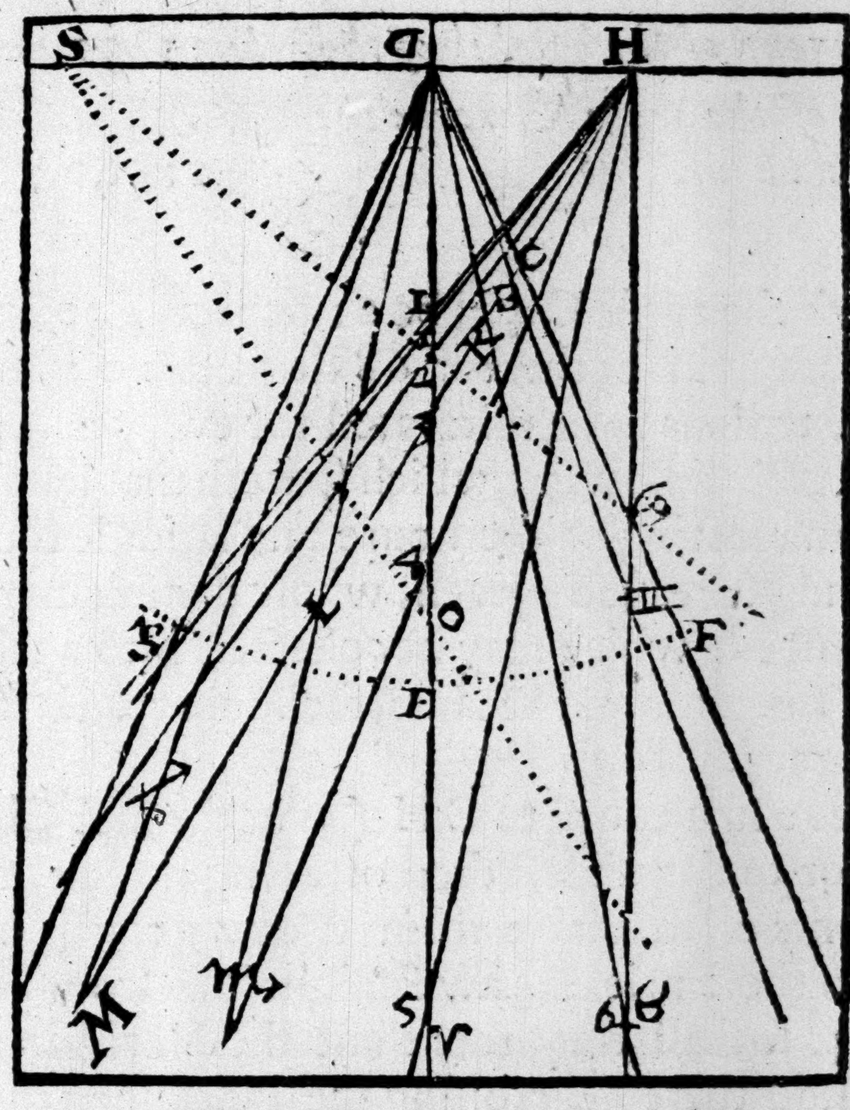
And againe, *by the same case.*

As	D C G *the sine of*	51 *d.*	32	9893.74
	And			
	D F G *the sine of*	38	28	9793.83
	Is to D G *in parts*	440		0355. 93.
So is	D G C And D G F *the sine of* 90 *d.* 0'.			10000.00.
	To D C *in parts*	562		9750. 33
	And			
	To D F *in parts*	708		9850. 24

Comple. Charact. 0.

Wherefore by a scale of inches, set of 35 hundred parts from C to G, and 23 hundred parts from G to K, and 55 hundred parts from G to F, and 165 hundred parts from G to H, and 56 hundred parts from C to D, and 71 hundred parts from D to F, and you shall find them justly to agree with the naturall tangents and secants aforesaid. This being done, returne to the trigone C F Ͼ, remayning the same with the former, crosse the middle line thereof C E at right angles in C, and let C H representing the axis of the stile, be equall to C D, and D C to D F of the Diall; Make D F the radius (which is evermore the secant of the heighth of the pole above the plane) and to that wideth open the

the Sector, then ſhall C 1. C 2. C 3. C 4. and C 5. be the Secants of 15 d. 30 d. 45, 60. and 75 d. the Equinoctiall diſtances of each houre from 12. by which you may pricke downe the houre diſtances from C upon the Æquator in the trigon.



Or rather making H C of the trigon the radius, equall to C D the axis of the ſtile in the Diall, which is the ſecant of 38 d. 28'. (euermore the complement of the heighth of the pole above the plane) C E ſhall be a tangent line to it: and to that wideth open the Sector or divide a line as aforeſaid) then ſhall C D, C 1. C 2. C 3. C 4. and C 5. be the naturall tangents, and H D, h 1. h 2. h 3. h 4. and h 5. ſhall be the ſecants of the complements of the houre arches at H, and are eaſily found *by the firſt and ſecond varieties of the ſecond caſe of R. S. triangles.*

For

	d.	′	Logar.
As the whole sine of	90 d.	0′.	10000.00
Is to the Cosine of 60 for 4 of clock, or of any other houres distance from 12.	60	0	9698.97
So is the cotangent of the heighth of the pole	51	32	9900.09
To the tangent of the angle betweene the Æquator and houre line	21	40	9599.06

Wherefore if the angle C 4 H be 21 degrees, 40′. the angle C H 4 is the complement thereof 68 degrees 20′. but because this were very tedious to be reiterated for every houre, I have calculated the table following, which spareth that labour, where in the common meeting of the houre and latitude the angles at D. 1. 2. 3. 4. and 5. are ready given, whose complements are the angles at H desired, which may be collected into a table, with their naturall Tangents and Secants, for more readinesse sake, as in the example adjoyning.

Now divide a line equall to C H (as in the first Chapter) or open the Sector to the widest thereof, being Radius, and set the severall tangents of this table from C downwards in the line C E ♈, and to those pricks draw straight lines from H, passing by D. 1. 2. 3. 4. so shall they represent the Meridian and houre lines on each side thereof, crossing the signes upon the Trigon.

Houres.		*Angles at the Equator.*		*Angles at H.*		*Tangents*	*Secants.*
		d	′	d	′		
12	0	38	28	51	32	1258	1607
11	1	37	30	52	30	1303	1643
10	2	34	32	55	28	1453	1764
9	3	29	20	60	40	1781	2042
8	4	21	40	68	20	2517	2708
7	5	11	37	78	23	4864	4966

at the same distances from H, that their paralels will doe from C the center of the Diall; if you like to put on these houre lines by a scale of Inches, worke *by the second Case of R.P. Triangles.*

For		*Logar.*
As C H *the radius in the trigon*		+ 10000.00
Is to the line G H *equall to* C D *the axis of the stile*	562	—0250.27
So is C 4 *the tangent of the angle* C H 4	68 *d.* 20′.	+10400.91
To the line C 4 *in like parts of* C H	1415	+0150.64

Therefore C 4 is one inch and 42 hundred parts next hand; and so of the rest.

Now if these lines be presumed to be truly drawne without errour, (which is hard to doe) you may from this Trigon thus drawn, prick down the paralels upon the Dials: but for the arithmeticall worke (which I rather wish you to trust to) it were sufficient to draw these lines by hand, somewhat neere the matter, onely to helpe the fancy in the rest of the worke, which is thus; In the triangles C G H, C B H, C K H, and C L H &c. the angle at C is alwayes given lesse then 90 d. in the signes betweene H and the Æquator, and more then 90 degrees in the rest, the quantity of each paralels declination; the angles at H are found in the table aforesaid, and the angles at G. B. K. and L, are the complements of them both to a Semicircle, which being found, the proportion is plaine, *by the first case of O.P. triangles:* For as the sines of C G H, C B H, C K H, and C L H, are to the line CH 562 in parts of an inch: or rather to the Radius, 1000, so are the sines of the Diall upon the houre lines of 3 and 9; for more plainnesse thus.

The angle C H G *is*	60 *d.*	40
The angle H C G *the complement of the declination*	66	29
Added together	127	9
Therefore C G H *the complement to* 180 *d. is*	52	51

			Logar.
As the sine of the angle C G H	51 *d.*	32′.	9901.49
Is to the line C H	1000		0000.00
So is the sine of the angle G C H	66	29	9962.34
To the line H G	1150		0060.85

From

From a line divided equall to C H, or off the sector (opened to that wideſt) take 1 length, and 15 hundred parts of another, which ſet from the center of the Diall, ſhal give the points a and b upon the houre lines of 3 and 9 of clock of the horizontall for the tropique of ♋, do the like with the reſt, varying the angle at C according to the declination of the paralell, which is alwayes acute for the ſignes betweene the point H and Æquator, but obtuſe in the reſt; you may yet ſhorten this worke after this manner, and either calculate the diſtances of all the paralels at once upon each houre line by it ſelfe, or of each paire of paralels upon all the houres together; as in theſe examples following.

The angle C 3 H, *in the table above writ-tenis*	29 d.	20′.	*Coſines.*
The declinations of the paralels with their Coſines.	23.	31	9962.34
	20.	13	9972.38
	11.	31	9991.17
			Arith. Compl.
The arch of the houre added to the declination with the Arithmeticall Complement of each ſine, to auoid ſubtraction.	52 d.	51′.	0098.61.
	49.	33	0118.63.
	40.	51	0184.36.

Diſtances from H. or from the center of the Diall.

		Logar.
1 150	♋ HG	X0060.85
1 233	♊ ♌ HB	X0091.01
1 498	♉ ♍ HK	X1175.53

The declinations ſubducted out of the arch of the houre with their Arithmeticall Complement alſo.	05 d.	49′.	0994.19.
	9	7	0800.11.
	17	49	0514.31.

9 048	♑ HN	X0956.53
5 922	♐ ♒ HM	X0772.49
3 102	♍ ♓ HL	X0505.48

Adde

Adde the Cosine of 11 d. 31′. unto the Arithmeticall Complement of 40 d. 51′. and 17 d. 49′. so have you new Logarithmes, which found in the *Chiliades*, gives 1498 for HK the distance of ♉ and ♍, and 3202 for HL, the distance of ♏, and ♓, doe the like with the Cosine of 20 d. 30′. for 49 d. 33′. and 9 d. 7′. as also with the Cosine of 23 d. 31′. for 52 d. 51′. and 5 d. 29′. so have you the distances of the rest of the signes, *viz.* HG for ♋, 1150 and HN for ♑ 9048, HB for ♊ ♌ 1222, and HM for ♐ ♒ 5922, all which being set from the center of the Diall C upon the houre lines of 3 and 9 give you points for the paralels of the signes in those two houre lines; and the like must be done for the rest.

In calculating each paire of paralels together, you may make use of the former table, which here I transcribe.

Houres.		*Angles at the Equator.*		*Angles at H.*		*Tangents*	*Secants.*
		d	′				
12	0	38	28	51	32	1258	1607.HD
11	1	37	30	52	30	1303	1643.H 1
10	2	34	32	55	28	1453	1764.H 2
9	3	29	20	60	40	1781	2042.H 3
8	4	21	40	68	20	2517	2708.H 4
7	5	11	37	78	23	4834	4966.H 5

Then adde 23 d. 31′. the declination of ♋ and ♑ unto each houres arch, and subduct it from them, unto the Arithmeticall Complements of the new arches made by addition and subtraction, adde the cosine of the declination (so have you new Logarithmes, which found in the *Chiliades*, will give the distance of those two paralels upon each houre line from the center of the Diall. But if the Diall have no center upon the plane (as in the example of the 11 Chapter) or that the lines be to long from the

	d	'	Arith. Complement.	Logarith.	Lines from the Center.	Lines from the Equator.	Houres.		
Declination of ♋ and ♑.	23	31	9962.34	*Cosine.*					
Added to each hou. arch composeth these,	35	8	0239.96	10202.30	1593	3373	7	5	
	45	11	0149.13	10111.47	1192	1416	8	4	
	52	51	0098.51	10060.85	1150	0890	9	3	♋
	51	3	0071.33	10033.67	1081	0583	10	2	
	61	1	0058.11	10020.45	1048	0595	11	1	
	61	59	0054.17	10016.47	1039	0568	12	0	
And subducted out of the same, leaveth these.	5	49	0994.19	10956.53	9048	7006	9	3	
	11		10718.75	10681.09	4798	3034	10	2	♑
	13	59	0616.83	10579.17	3795	2151	11	1	
	14	57	0588.42	10550.76	3554.H.♑	1947.D.♑	12	0	

the center, abate the lines of each houre from the center, as for 12, 1039, with the rest belonging to ♋, out of the secants of the same houres above written; which are the distances from the center to the Æquator: and the secants themselves, out of the distance of the houres, as for 12, 3554 with the rest of the lines belonging to ♑. So shall you have new lines to be set both wayes from the Equinoctiall, as formerly from the center; Thus if you take H 3 of the trigone 2040, out of H L 3202, there will remaine 3 L, 1160, from the Æquator to ♏, and if you take HD. 1607 out of H ♑ 3554, there will rest D ♑ 1947, the distance of ♑ from the Æquator upon the 12 of clock houre; and so of the rest. The paralells upon the 6 of clock houre, H ♋♉ are the very same with the polar, whose distances from the center are H ♋ 209. H ♊ 271, and H ♉ 491, the naturall tangents of the complements of the declinations of ♋♊ and ♉ making CH the Radius. Of all which I have discoursed the more at large, because the same rules will serve in the rest that follow.

South

South[illegible], North direct.

In South and North planes the heighth of the stile or pole above the plane is the complement of the former above the Horizon; if therfore C H 2 Inches the distance of ♋ from the center, in the Diall of the seventh Chapter, be thought convenient for the plane, first find out the length of the perpendicular stile G D, as afore, which being Radius, G C shall be 1259 the naturall tangent of 51 d. 32′. and G H 1879 the naturall tangent of 61 d. 59′. the Meridionall heighth of ♋, (because C H is a tangent line to the Radius D G.) Wherefore

		Logar.
As C H both tangents together	3138	+0496.65
Is to C H two inches	2 *in:*	+0310.03
So is G D the Radius	1	+0000.00
To G D in hundred parts of an inch	650	9813.38

Comple. Charact. 0:

Or you may find the length of G D by the Arithmeticall complement of 3138 as before; take 65 hundred parts of a scale of inches, and open the Sector to that width, then set 1259 the naturall tangent of 51 d. 32′. from C G, and by it draw the perpendicular stile G D, paralell to 6 C 6, set 267 the naturall tangent of 14 d. 57′. the meridionall heighth of ♑, from G to K, and K shall be the point, by which the paralell of ♑ shall passe: let 704, the naturall tangent of 38 d. 28′. from G to F, and by F draw a paralell to 6 C 6, which shall be the Equinoctiall: set 1879, the naturall tangent of 61 d. 59. the Meridionall heighth of ♋, from G to H, and H shall be the point, by which the paralell of ♋ shall passe.

This done, returne to the trigone, and supposing the houre lines of the horizontall to be taken of, let C S be equall to C D, the axis of the stile of the South Diall, and C 2 equall to D F the

Radius of the Æquator thereof; out of the table following take the angles of the houre arches, under the latitude of 38 d. 28′. (which is the heighth of the stile above this plane) and collect them, with their naturall tangents, and secants into a table, for more ease sake, as in the example.

Houres.		Angles at the Equator.		Angles at S.		Tangents.	Secants.
		d	′	d	′		
12	0	51	32	38	28	794	1277
11	1	50	30	39	26	822	1295
10	2	47	28	42	32	917	1357
9	3	41	39	48	21	1124	1505
8	4	32	11	57	49	1589	1877
7	5	18	2	71	58	3072	3227

Then making C S Radius, C E shall be a tangent line to it: wherefore set the tangents of this table from C downwards, upon the line C E ♈, and you shall have pricks therin, by which straight lines drawne from S (as is the prickt line S 2. for 11. and 1 of clocke, and S O for 8 and 4 of clocke) shall give the houres of the South Diall, crossing the paralels upon the trigon at the same distances from S, that they will doe from the center of the Diall, the length of which lines are to be found in all respects as the former were, and therefore needlesse to repeate the worke againe.

South and North recliners.

In South and North recliners, the rules of the horizontall doe ex-

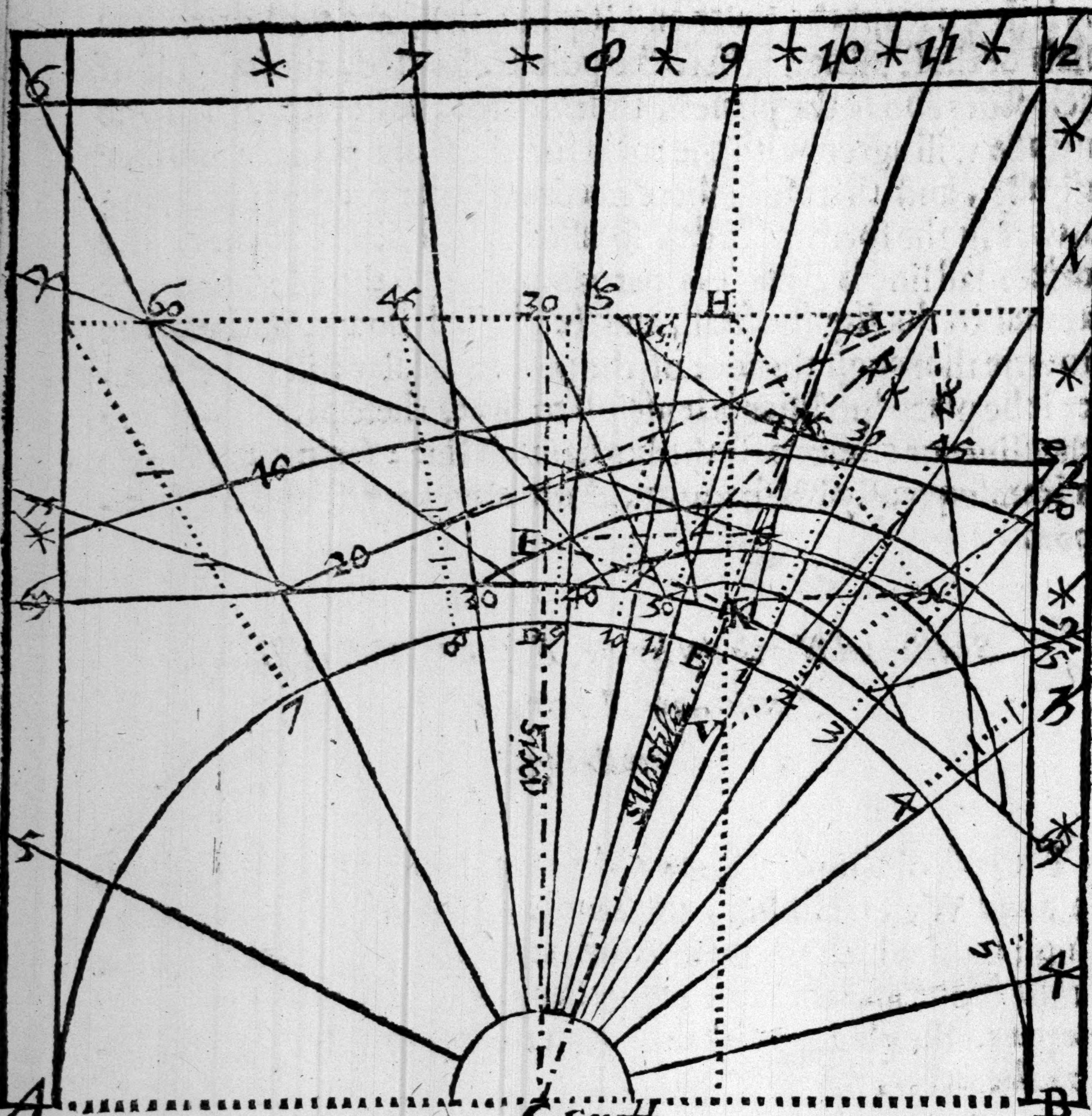
exactly hold without alteration at all: for seeing that all their varieties, except the Polar and Equinoctiall, are the horizontall Dials of those places, where the pole is elevated, the heighth of their stiles above the planes, the rules for the horizontall in one latitude will agree with the rules for the same plane in another latitude, and therefore there needs no other precept for them; now as in the former kinds, so also in these direct planes, the horizontall line is alwayes a perpendicular to the Meridian, or paralell to the Equinoctiall, and six of clock houre, and must be drawne thorough the foot of the perpendicular stile, wheresoever it be placed; neither is it usefull to draw these paralells or any other lines or circles past the horizontall line: seeing the Sunne and consequently his shadow, doth alwayes rise and set thereupon.

South and North declining. East and West reclining. South and North declining reclining.

The rest of the planes, are either South and North declining, East and West reclining, or South and North declining reclining; in all which the manner of inscribing the paralels of the Sunne is one and the same; whether you worke with the houres proper to the plane, or by this briefer way, which I preferre before the other.

Every one of these latter planes is an horizontall plane, to some place or other agreeing in longitude with the angle betweene the two Meridians; and in latitude with the heighth of the stile above the plane.

Wherefore suppose the substile T P T L of the declining Diall in the 11 Chapter, and C G of the declining reclining Diall in the 17 Chapter, to be (as indeed they are) the Meridians of the horizontals, in longitude and latitude proper to them; upon which first of all pricke downe the place of the perpendicular stile, the two Tropiques, and Equinoctiall, which by the heighth



of the Sunne in those points upon the substile is easily attained; in ths Diall of the seventh Chapter, the heighth of the stile, or pole above the plane, being 19 degrees 25′. the heighth of the Equinoctiall is 70 d. 35′. the complement thereof, to which adde and subtract 23 d. 31′. the declination of the tropiques, so have you 94 d. 6′. whose complement 85 d. 54′. is the heighth of the Sunne in ♋, and 47 d. 4′. the heighth in ♑. Now because the Equinoctiall is alwayes a straight line, cutting the substile

stile

stile at right angles; first assigne the place thereof, where you will, but so that it may crosse most of the houre lines, and stand convenient for the plane, as it doth at G in the Diall aforesaid; take the length of C G in some knowne parts, suppose 2 17 that is two inches, and 17 hundred parts; by this line proportion the rest; for *by the first and second of R.P. Triangles.*

			Logar.
As the radius GFC	90 d.	0'.	+ 10000.00
Is to the line CG	217		+ 0336.46
So is the sine of CGF	70	35	+ 9974.57
And of GCF	19	25	+ 9521.71
To the axis of the stile CF	205		+ 10311.03
And to the radius of the Æquator GF	72		— 19858.17

Complement Characteristical 0.

And againe, by the same Cases.

			Logar.
As the radius CKF	90 d.	0'.	+ 10000.00
Is to the line CF	205		+ 0311.03
So is the sine of KCF	19	25	+ 9521.71
To the length of the perpendicular stile KF *in parts of an inch.*	68		— 19832.74

Charact. Complement 0.

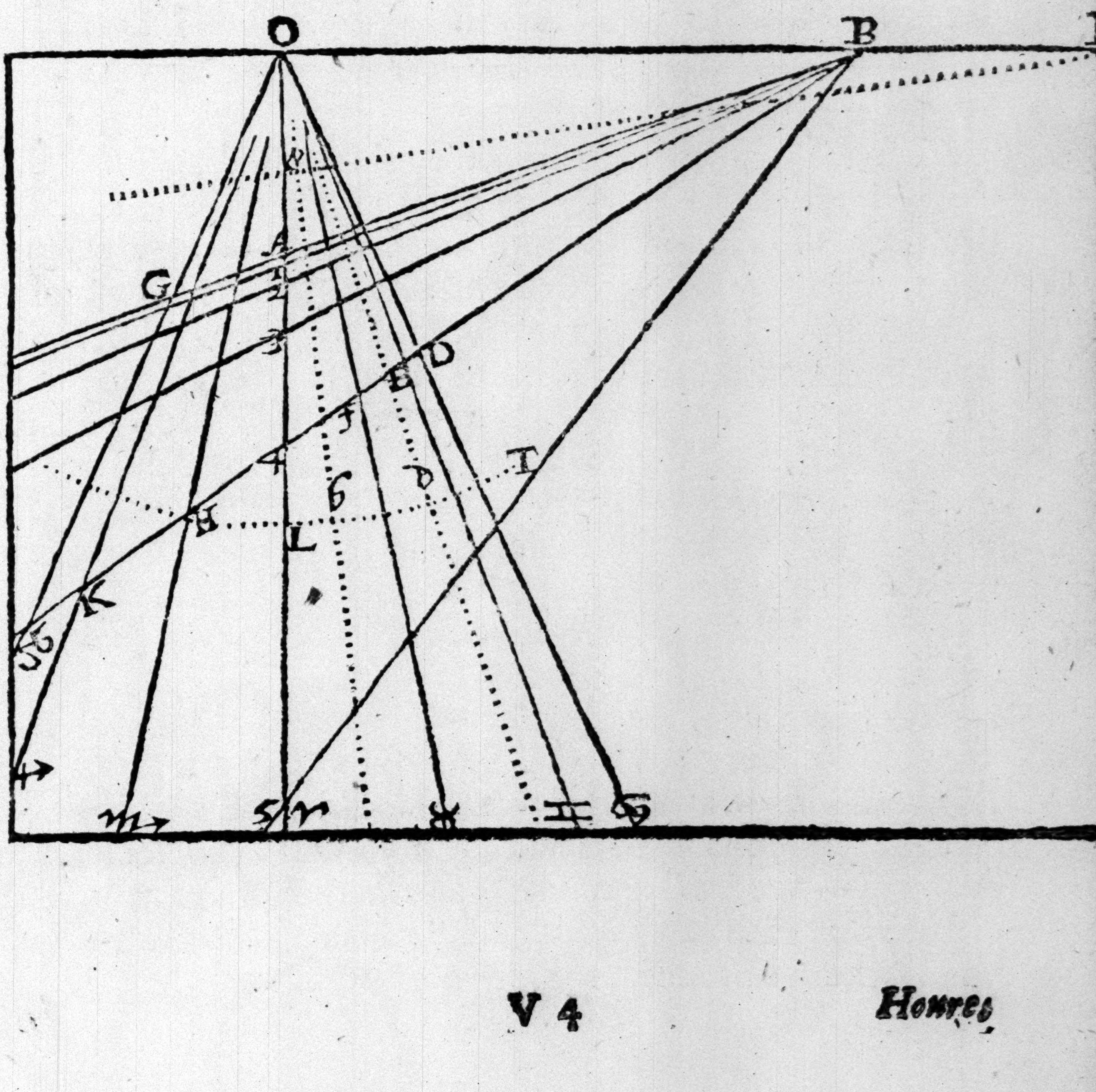
If you like to use the Sector or a line divided into 10 or 100 parts, instead of the scale of inches, you may find the same K F with more facility, by adding the naturall tangents of C K and K G, (the heighth of the pole above the plane, and complement thereof) together, or by taking the Arithmeticall complement of the Logarithme of those two tangents, 3 162 &c. as is

is directed in the horizontall, which giveth 316 parts of the Sector, equall to 68 parts of an inch, as abovesaid.

Having found the length of the stile K F, you may finde the place thereof of the tropiques and Equinoctiall upon the Substile, in inches and parts, by resolving the triangles F C K, F G K, and F T K of the Diall &c. but I doe rather commend the use of the naturall tangents, as both the speedier, and the easier worke; for making K F the radius, C K T shall be a tangent line to it: wherfore divide a line equal therto (as in the first Chap.) or open the Sector to the width thereof, and from either take 2837, the naturall tangent of 70 d. 35′, and set it from C to K for the place of the stile, or 352 the naturall tangent of 19 d. 25′, from G to K the point formerly assigned for the Æquator; set 072 the natural tangent of 4. d. 6′, the complement of the heighth of the Sun in ♋, from K towards the center, for the paralell of ♋: and set 93 the naturall tangent of 42 d. 56′, the complement of the heighth of the Sunne in ♑ from K to T, for the place of the Tropique of ♑, and thus you may proceed with all planes that cut the axis, both with the intermediate signes, and paralels of declination upon the substile. This done, let H O in the one example, and G F in the other, be radius: (which in all Dials is the secant of the heighth of the pole, or stile above the plane) unto which the Sector being opened (or from two lines divided equall to them, into ten parts) you may by helpe of the naturall tangents of 15 d. 30 d. 45 d. 60 d. and 75 d. pricke downe upon the Equinoctiall, on each side of the substile, obscure houre lines, as if you were to draw an ordinary horizontal Diall upon that plane: because the Equinoctiall line ♈ G ♎ is a tangent line to the Radius F G; the first paire of them shall be instead of 1 and 11, the second of 2 and 10, the third of 3 and 9, the fourth of 4 and 8, the fift of 5 and 7, as are the prickt lines marked with 7. 8. 9. 10 11. 12. 1. 2. 3. and 4. in the 11 and 17 Chapters aforesaid, the six of clock houre (if there be cause to use it) is alwayes paralell to the Equinoctiall, neither are these lines to be blotted out againe (as in some cases the like be) but rather to be distinguished by small pricks (as in both the examples of the former Chapters you

you see done) seeing besides this use of inscribing the paralels, they also serve to shew the true houres of that Country where this plane is horizontall.

This done draw the trigon O ♌ ♋, as before directed in the 25 Chap. and crosse it at right angles with O B, let O B be equall to the axis C F, and O A to G F, in the declining reclining Diall of the 17 Chapter. Next, out of the table following, under the latitude 19 degrees 25'. (which is the heighth of the pole above this plane) take the houre arches (corrected by proportion) and collect them with the naturall tangents and secants into a table, as here is done.



Houres.		*Angles at the Equator.*		*Angles at B.*		*Tangents.*	*Secants.*
		d	'	d	'		
2	0	70	35	19	25	352	1060
11	1	69	57	20	3	365	1064
10	2	67	52	22	8	407	1079
9	3	63	30	26	30	498	1117
8	4	54	49	35	11	705	1227
7	5	36	18	53	42	1361	1689
6	6	0	0	0	0	*Infi:*	*Infi:*

Then making O B the axis of the stile the Radius, O L ♈ shall be a tangent line to it: wherefore set off the tangent of every houres arch, *viz.* 352, 365, 407, &c. from O downwards upon the line O ♈, and by the pricks 1.2.3.4. and 5. draw straight lines from B, which shall represent the prickt houre lines of the Diall crossing the paralels of the signes upon the Trigon, at the like distances from B, that the same paralels wil doe the said lines from the center of the Diall; having the angles at the Equinoctiall, and their complements at B ready given in this Table, you may by the very same rules of the Horizontall, find the distances of B D, B E, B F, B H, B K, and B ♋, upon that houre line of 4 and 8, and in like manner upon all the rest, for as the angles O B D, O E B, O F B, &c. are to the side O B in parts of a scale of inches (or as radius supposed to be divided into 1000 parts) so are the angles D O B, E O B, F O B, &c. unto the lines B D 936. B E 971. and B F 1070 and so of the rest; which taken of the Sector, or a line divided equall to O B, and set from the center C of the Diall upon the prickt lines of 8 and 4, give the distances of each paralell upon those houre lines; and so must you worke with the rest of the houre lines also.

De-

Decliner without a center.

Laſtly, for the decliner of the eleventh Chapter, without a center, the rules are the very ſame with this former; but becauſe the axis of the ſtile, which is there found to be 29 inches 79 hundred parts, is too long to put upon this Trigon, take the tenth part thereof, which is two inches 98 hundred parts, and ſet that diſtance from O to R, and making O R the Radius, divide a line equall thereto into ten parts: or open the Sector to that wideſt, and ſet of the naturall tangents of each houres arch in the table adjoyning, from O downwards upon the line O ♈, & thorough thoſe pricks draw ſtraight lines from R, repreſenting the prickt houre lines of the Diall, croſſing the paralels of the ſignes, as doth the prickt line R 8 for 8 and 4 of clock in the trigon. This done, proceed in the calculation in all reſpects as formerly, which being already ſufficiently explaned, I will onely adde this example of calculating the two Tropiques together, as in the latter inſtance of the horizontall.

And note, that having found the diſtances from the center, you muſt ſeeke them alſo by the former rules of the horizontall from the Equinoctiall, as are H 12, æ 1, æ 2, æ 3, and æ 4, becauſe the Diall hath no center to ſet them from.

Now you might by the ſame rules but (with much more labour) find out the paralels upon the houre lines themſelves, of theſe laſt ſorts of Dials: but I preferre this way. Firſt, becauſe you have two Dials contrived into one, not unpleaſant to behold. Secoudly, the whole worke is the ſame, in theſe ſeverall ſorts, without variety or change; and laſtly, becauſe the one halfe of the labour is ſaved, there being but ſixe houres at the moſt to worke upon after this manner, which are 10. 11. & 12. in moſt ſorts beſides.

Houres

Houres.		Angles at the Equator.		Angles at R.		Tangents	Secants.
		d	'	d	'		
12	0	86	2	3	58	069	1002
11	1	85	54	4	6	072	1002
10	2	85	25	4	35	080	1003
9	3	84	24	5	36	098	1005
8	4	82	6	7	54	139	1009
1/2	½	79	44	10	16	181	1016

Declination of ♋ and ♑.			Arith. Complement.	Logarith.	Lines from the Center.	Lines from the Equator.		Houres	
	23	31	9962.34						
	d	'							
Added to	109	33	0025.78	9988.12	973	29		12	
each hou.	109	25	0025.42	9987.76	972	30		1	
archcom-	108	56	0024.15	9986.49	969	34		2	
poseth	107	55	0021.58	9983.92	964	41		3	
these,	105	37	0016.33	9978,67	952	57		4	
	103	15	0011.71	9974.05	942	74		4½	
				o cõpl. char					
And sub-	62	31	0052,00	~~1~~0014.34	1034	32	H.12	12	0
ducted	62	23	0052,52	~~1~~0014.86	1035	33	æ. 1	1	
out of the	61	54	0054.46	~~1~~0016.80	1039	36	æ. 2	2	
same, lea-	60	53	0058.66	~~1~~0021.00	1050	45	æ. 3	3	
veth	58	35	0068.84	~~1~~0031.18	1074	65	æ. 4	4	
these.	56	13	0080.31	~~1~~0042.65	1104	88		4½	

CHAP

CHAP. XXVIII.

To deſcribe the diurnall arches upon any Plane.

THe paralels of the ſignes, and the diurnall arches are one and the ſame circles in the *Sphere*, differing onely in the quantity of their declinations from the Equinoctiall in ♋ and ♑, they are coincident in ♉ & ♌, ♏ and ♒, they differ but very few minutes; wherefore if you would inſcribe them on any of the dials before mentioned, let the middle and outward lines of the *Trigon* remayne, but the intermediate muſt be drawne (by helpe of the chord) on both ſides of the Equinoctiall, at the diſtances of the declinations deſired, the reſt of the worke continuing the ſame as afore. So if you will put on the diurnall arch of 9 houres or 15: take of the chord the arch of declination 16 d. 55′. and for 11 and 13 houres, the declination of 5 d. 55′. anſwerable to the ſemidiurnall arches: and ſet them both wayes from L to b and d in the prickt circle L T of the former Diagram, and draw ſtraight lines from O to b and d, and ſo of the reſt, which you may find ready calculated in this Table; the Trigon being filled with diurnall arches, in ſtead of the ſignes, and the houre lines croſſing them, as formerly they did the ſignes, afford you Triangles, which being reſolved, according to the former rules, give the diſtances of the diurnall arches, either from the center, or from the Equinoctiall, as is moſt convenient for your worke.

To calculate this Table or the like, firſt convert the ſemidiurnall arches into degrees and minutes, allowing 15 d. for one houre: and 15′. for one minute of time, ſo ſhall 56 d. 47′. anſwere to 3 houres, 47′. and 60 d. to 4 houres, and ſo of the reſt; Then *by the firſt of the fiſt caſe of R. S. triangles.*

Houres

stant from the Equinoctiall, or not, as is fittest for the plane, suppose ♋ and ♑, *by the second of the fourth case of R. S. triangles,* find the semidiurnall arches in degrees and minutes. For

			Logar.
As the cotangent of the latitude	51 d.	32'.	9900.08
Is to the tangent of the greatest declination	23	31	9638.65
So is the Radius	90	0	10000.00
To the cosine of the semidiurnall arch of ♑ *and seminocturnall of* ♋	56	47	9738.57

Therefore the semidiurnall arch for ♑, is 56 d. 47'. and the complement thereof to 180 d. *viz.* 123 d. 13'. is the semidiurnall arch for ♋; double these arches, and divide each of them by 12, so shall you have 20 d. 32'. for one twelfth part in ♋, and 9 d. 28'. for one twelfth part in ♑, and so by addition proceed to six twelve parts, convert these degrees and minutes into time, allowing 15 d. to one houre, and foure minutes to one degree, and marke their distances upon both Tropiques, each way from the houre of 12 (in which both kind of houres concurre to be the same line) so shall you have 3 pricks, *viz.* two in the Tropiques, and one in the Equinoctiall (every unequall houre crossing one of the ordinary houres in the Æquator) by which to draw each houre line, as in this Table appeareth, wherein the fift and seventh unequall houres are distant from 12. in the paralell of ♋ 1 houre, 22'. but in ♑ 0 houre 38'. and must passe thorough 11, and 1 of clock in the Equinoctiall; the fourth and eight houres are distant from 12. two houres 44'. in ♋, and 1 houre 16'. in ♑ and passe thorough 10 and 2 of clocke in the Equinoctiall, and so of the rest.

But if instead of the signes, the diurnall arches be inscribed in your Diall, you may much more easily and precisely worke by them, especially if your plane will receive the ninth and 15 paralels; because the distances of every twelfth part of them from the Meridian, will justly fall upon the houres, halfes, and quarters formerly drawne; first therefore reduce these paralels into de-

The unequall houres from 12.		*The paralels of* ♋ *in*				*The Equinoctiall.*		*The paralel of* ♑ *in*			
		D	M	H	M	H	H	D	M	H	M
H	H										
5	7	20	32	1	22	11	1	9	28	0	38
4	8	41	4	2	44	10	2	18	56	1	16
3	9	61	36	4	6	9	3	28	24	1	54
2	10	82	9	5	29	8	4	37	51	2	31
1	11	102	41	6	51	7	5	47	19	3	19
12		123	13	8	13	6		56	47	3	47

degrees and minutes, allowing as afore, ſo ſhall the paralell of 9 houres containe 135 d. and of 15 houres 225 d. divide each number by 12. the quotient will be 18 d. 45′. for one 12 part in the paralell of 15 houres, and 11 d. 15′. for one 12 part in the paralell of 9 houres, and 37 d. 30′. for two 12 parts in the paralell of 15 houres, and 22 d. 30′. for the like two 12 parts in the paralell of 9 houres, and ſo of the reſt; convert theſe degrees and minutes into time (allowing as aforeſaid) and each 12 part of theſe paralels will fall out upon the houres, halfes, and quarters, and therefore their diſtances from 12 the more eaſily and exactly marked upon each paralell, which done, you have 3 pricks (as afore) *viz.* two in the paralels of 9 and 15. and one in the Equinoctiall, by which to draw every unequall houre, as in this Table appeareth, wherein the fift and ſeventh unequall houres are, diſtant from 12 in the 15 paralel 1 houre 15′. in the 9. 0. ho. 45′. and muſt paſſe thorough 11 and 1 of clocke in the Equinoctiall; the fourth and eighth houres are diſtant from 12 in the 15 paralell two houres 30′, in the ninth 1 houre 30′. and paſſe thorough 10, and two of clocke in the Equinoctiall, and ſo of the reſt, and note that theſe Tables thus prepared, ſerve generally for all planes in this latitude.

The

The unequall houres from 12.		*The paralels of 15 Houres in*				*The Equinoctiall.*		*The paralel of 9 Houres in*			
		D	M	H	M	H	H	D	M	H	M
H	H										
5	7	18	45	1	15	11	1	11	15	0	45
4	8	37	30	2	30	10	2	22	30	1	30
3	9	56	15	3	45	9	3	33	45	2	15
2	10	75	0	5	01	8	4	45	0	3	0
1	11	93	45	6	15	7	5	56	15	3	45
12		112	30	7	30	6		67	30	4	30

CHAP. XXX.

How to describe the Azimuthes and Almicanters upon each Plane.

THere are also three various inscriptions of the Azimuthes and Almicanters, as there were of the signes and diurnall arches; according as the Planes whereon they are described, doe cut the axis of the Horizon, rightly, obliquely, or are paralel thereto; the polar plane is to the pole of the World, the houre circles and the paralels of declination, in all respects, as the Horizontall is to the Zenith, the verticall circles, and the paralels of the Horizon; wherefore as in the first sort the plane cutteth the axis of the World, at right angles, and the houre lines doe meet at equall angles in the center, representing the pole, and the paralels of declination doe crosse them with perfect circles, so in the latter sort the plane doth cut the axis of the Horizon at right angles, and the Azimuths doe meet in the place of the perpendicular stile, representing the Zenith or pole of the Horizon at equall angles; and the Almicanters are perfect

circles

circles crossing the same; whatsoever therefore is said of the one, may be understood of the other, neither needs there any further directions for the same; yet for more plaines, I will adde this example. Let F E in the Scheme adioyning represent the Meridian line, passing by G the foot of the stile in the Horizontall Diall; G in the Diall, and F in this Diagram shall be the Zenith, or center of all the azimuths; upon which describe the obscure arch E B, equall to A B 60 d. of the chorde, and by helpe of the same chorde, pricke downe thereupon the arches of 10 d. 20 d. 30 d. 40 d. 50 d. &c. or what other you thinke fit: straight lines drawne from G in the Diall, as here they are from F, thorough the pricks aforesaid, are the true azimuthes desired; Let F B be drawne perpendicular to F E, and therein make F H equall to G D the perpendicular stile of the Diall, and draw H 1, paralell to F E, the lines H 6. H 5. H 4. H 3. H 2. and H 1. be the semidiameters of the Circles, describing the almicanters upon the circle G of the horizontall: whose lengths are thus easily found, if you will worke by a scale of inches. For

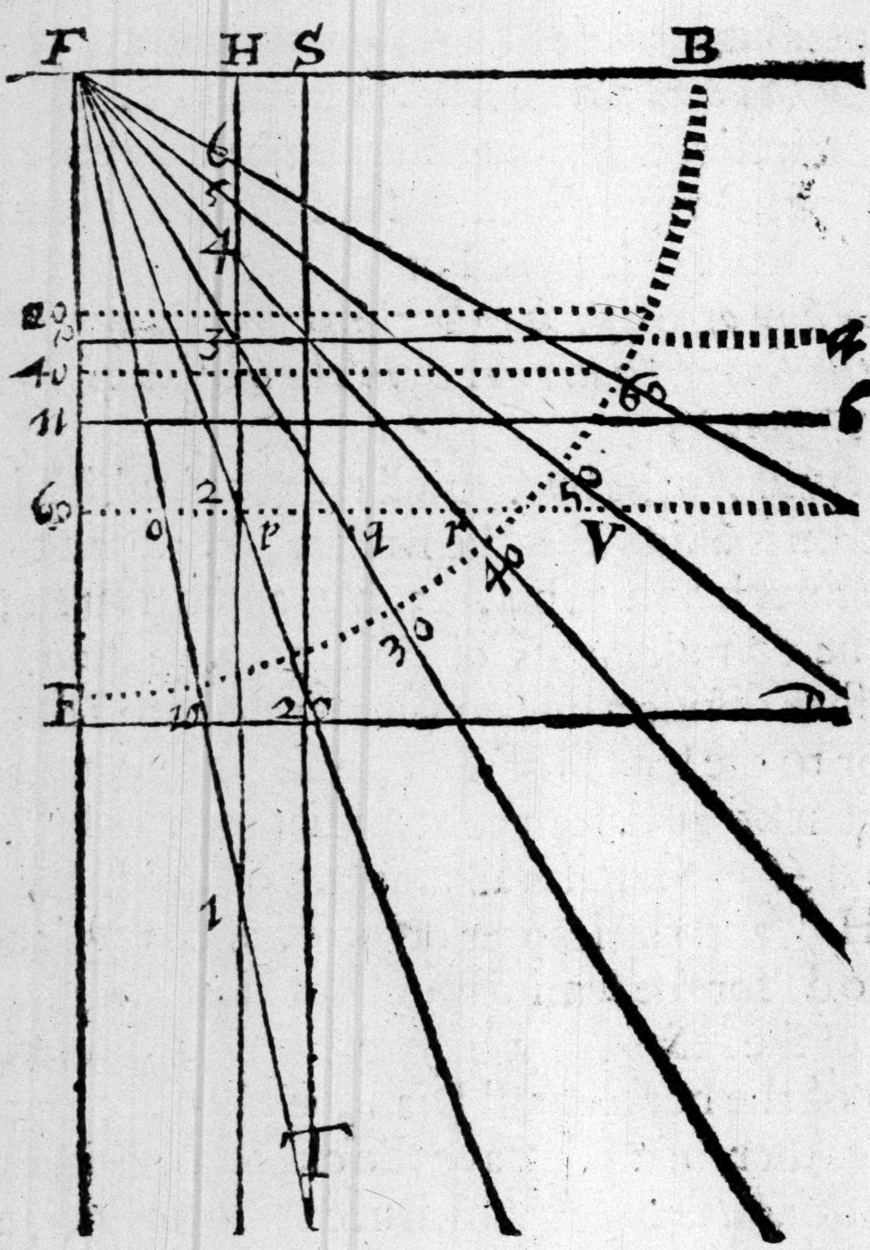
As F 6 H *the sine of* 60 d. *is to* F H *in hundred parts of an inch*; *So is* H F 6. *the sine of* 30 d. *to* H 6, *in the like parts, by the second case of R.P. Triangles.*

But if you will worke by naturall tangents, which is farre the easier way, then making F H the Radius, H 31 is a tangent line to it, and the lines h 6. h 5. h 4. h 3. h 2. and h 1. are the naturall tangents of the complements of 60 d. 50 d. 40 d. 30. 20 d. and 10 d. wherefore divide a line equall thereto into 10 parts, or open the sector to the length of F H, and take thereof $\frac{577}{}$, the naturall tangent of 30 d. for the Semidiameter of H 6. the almicanter of 60 d; $\frac{839}{}$ the naturall tangent of 40 d. for the semidiameter of H 5. the almicanter of [50 d. and $\frac{1192}{}$ the naturall tangent of 50 d. for the semidiameter of H 4, the almicanter of 40 d. and so of the rest; All which circles, being described upon the center G of the horizontall Diall, as they are marked with 60. 50. 40 &c. thereon: you have the circles of altitude, or paralells of the Horizon desired; which need not be drawne past the tropiques of ♋ and ♑ in the Diall, because the apex of the stile which giveth the shadow, cannot exceed those limits.

CHAP. XXXI.

The second sort.

ALL upright planes are paralell to the axis of the Horizon, as all the Equinoctiall planes are to the axis of the World; and therefore the Azimuths in those, as the houre lines in these, are paralell one to another; such are the South and North direct, the East and West direct, and all South and North declining planes; wherefore let F E of the Diagram



ad

adjoyning represent the horizontall line of the South Diall, Chapter seventh, drawne thorough the foot of the stile G, parallell to the 6 of clock houre; and let F B crosse it at right angles, upon the center F; describe an obscure arch of a quadrant E B, equall to A B of the chord; and therein inscribe by helpe of the chord, the Almicanters of 10 d. 20 d. 30 d. &c. as formerly you did: make F S, equall to G D, the perpendicular stile of the Diall; and draw S T paralel to F E: These things prepared, you may first inscribe the Azimuthes on the Diall, and then transferre them to this Diagram, for finding the Almicanters in this manner; Let G D the perpendicular stile in the South Diall, equall to G X, be supposed to be perpendicular to the horizontall line thereof; and making G X the Radius, the horizontall line 7 G 5 shall be a tangent line thereto, and the naturall tangents of 10 d. 20 d. 30 d. 40 d. &c. prickt downe from G upon the horizontall line both wayes, *viz.* 364 for 20, and 839 for 40 d., &c. as in the Table adjoyning: and by those pricks parallels drawne to the 12 of clock houre in the Diall (as are 20. 40. 60 and 70) shall give the true Azimuths desired; you may likewise, knowing the length of G X, or G D in parts of an inch, and the angles of the Azimuths at X with their complements upon the horizontall line of the Diall, find the same distances in the like parts, for as

Azimuths.	*Tangents.*	*Secants.*
d		
10	176	1015
20	364	1064
30	577	1155
40	839	1305
50	1192	1556
60	1732	2000
70	247	2924
80	571	5759

the angle G L X of the 60 Azimuth, is to the line GX in parts, so is the angle G XL, the complement of the former, to the line G L in like parts, *by the 2. Case of R. P. Triangles*, and so of the rest; but to worke by naturall tangents, is the speedier way; The Azimuth being thus drawne, you may transferre them into this Diagram, either by taking the distance of each Azimuth upon the horizontall line from X as X L for 60 d. for 40 d. X N &c. & setting from F downwards upon the line F E to F 20, fh, F 40. F n, F 60, and F E &c. or else making F S equall to G X the Radius, open the sector to that width, and set 1155 the secant of 30 d. from F to H, and 1732 the secant of 60 d. equall to X L, from F to 60 d. and 2924 the secant of 70 d. from F to E, and so of the rest, as in the table adjoyning, to which points raise perpendiculars, as are h a, n b, and E d, and they shall represent the azimuthes in the Diall, crossing the Almicanters of 10 d. 20 d. 30 d. 40 d. 50 d. &c. at the same distances from the line F E in the Diagram, that they will doe from the horizontall line of the Diall upon the azimuth answerable to them; and may easily be inscribed by naturall tangents, seeing the azimuths in the Diall are tangent lines to the severall secants X L and X N, &c. as the lines d e, v 60, a h &c. in the Diagram representing the azimuthes, are unto each Radius F h, F 60, F E, &c. representing the secants; thus you may find that F 60 equall to X L, being Radius. 60. o will be 176 the naturall tangent of 10 d. and 60 t and will be 364 the naturall tangent of 20 d. and 60 q, 577 the naturall tangent 30 degrees and 60 r. 839 the naturall tangent of 40 d. and so of the rest; all which being taken of he Sector, and set downwards from L, the intersection of the 60 azimuth with the horizontall line of the Diall, shall give prick upon that azimuth at 1. 2. 3. 4. 5. by which the severall almicanters must passe: doe the like with as many of the rest of the azimuths, as will serve your turn, (for upon all you need not) as upon the 20 and 40 azimuth, and upon e d for the 70 azimuth, so shall you have severall points in severall azimuths, thorough which one continued circular line being drawne, you have the almicanters desired; If instead of these tangents, you will use a scale of inches, first find the length of F

60,

60, in parts of an inch: then is the proportion plane, for *by the second Case of right angled plane triangles, as* F 60 *the radius, is to* F 60 *in knowne parts, so is* 60.0. *and* 60 p. *and* 60 q. *&c. the naturall tangents of* 10 *d.* 20 *d.* 30 *d. to the lines* 60. 0. 60 p. *and* 60 q. *in like parts as afore.*

East and West direct.

In like manner, if instead of F S in the Diagram, equall to the perpendicular stile of the South Diall, you take the length of A 3, or A 9 equall to A L the length of the stile of the East and West Dials in the ninth Chapter, and worke in all respects therewith (first drawing the Horizontall line B A C thorough the foot of the stile at A, and supposing A P equall to A L, to be perpendicular thereto) the same naturall tangents of 10 d. 20 d. 30 d 40 d. &c. (taken of a line divided equall to A P, or the Sector opened to the widest thereof) and set both wayes from A upon the horizontall line B A C, shall give you points therein, to which perpendiculars erected, you have the azimuths desired; as are 20. 40. 60. 70. &c. in the Diall of the ninth Chapter aforesaid. The azimuths being drawne, let the secant of each azimuth 20. 40. 60. 70 &c, (which is the distance from P the top of the stile, unto the intersections with the horizontall line) be a severall Radius, and the naturall tangents of 10 d. 20 d. 30 d. 40 d. &c. set from the horizontall line downwards upon each correspondent azimuth, shall give points, by which circular lines being drawne, you have the almicanters desired; so making A P the stile in the East Diall, equall to A L the Radius, the naturall tangent of 60 d. 1732 set from A to 60 gives the distance of the azimuth of 60 in the horizontall line, and making P 60 the secant of 60 d. 2000 the Radius, the naturall tangent of 10 d. 176. and the naturall tangent of 20 d. 364 and the naturall tangent of 30 d. 577 with the rest, set from 60 downwards upon that azimuth, shal give points therein, by which the almicanters must be drawne, as are marked with 1. 2. 3. 4. and 5.

South and North declining.

Laſtly, in the declining Diall of the 11 Chapter, let PO the length of the ſtile be perpendicular to the horizontall line VPR, which being Radius, the Azimuthes ſhall be tangents thereto, the firſt whereof (reckoning from the Eaſt as *Clavius* doth) muſt alwayes be perpendicular to the interſection of the Horizon, Æquator, and ſix of clock houre, as is 6 Z in the Diall aforeſaid, diſtant from the foot of the ſtile P, the complement of the declination, and in this example is 112 the naturall tangent of 6 d. 23′. which being added to 10 d. 20 d. &c. for the azimuthes to the Northward of 6, or ſubducted from 10 d. 20 d. 30 d. 40 d. 50 d. &c. for the azimuthes to the Southward, ſhall give arches, whoſe naturall tangents ſet both wayes from P, afford you pricks in the horizontall line for the azimuthes deſired; Thus I take 294 the naturall tangent of 16 d. 23′, and ſet it from P to 10, for the tenth azimuth: and 496 the naturall tangent of 26 d. 23′. and ſet it from P to 20 for the 20 azimuth to the Northwards; and 437 the naturall tangent of 23 d. 37′. for 30 d. and 2016 the naturall tangent of 63 d. 37′. for 70 d. and ſet them from P to the Southwards, to all which draw perpendiculars (as in the example appeareth) ſo have you the azimuthes deſired. Now making the ſecants of each of theſe azimuthes a ſeverall Radius, *viz.* o. 30 d. 1097 the ſecant of 23 d. 37′. for the azimuth of 30 d. and o. 70 d. 2250 the ſecant of 63 d. 37′. for the azimuth of 70 d. and opening the Sector to theſe widths, take of the naturall tangents of 10 d. 20 d. 30 d. 40 d. &c. as in the former table, and ſet them downwards from the horizontall line upon each azimuth, ſo have you pricks, by which the Almicanters continued into one circuler line of the ſame denomination, muſt certainly paſſe, as you ſee the circuler lines of 10 d. 20 d. 30 d. 40 d. and 50 d. doe in the example of the Chapter aforeſaid.

CHAP.

CHAP. XXXII.

Their third sort.

NOw in al the reſt, that is in South & North reclining; Eaſt and Weſt reclining; and South and North declining reclining; the planes cut the axis of the Horizon obliquely, and therefore the Azimuths (as in the like caſes the houre lines did) doe meet in a center with unequall angles. In theſe planes there are two zeniths, the one proper to the plane, alwayes in the foot of the perpendicular ſtile, the other peculiar to the place, alwayes in the Meridian or 12 of clock houre line, but more or leſſe differing from the former, according to the nature and ſite of the plane; and as the zeniths, ſo doe the horizontall lines alſo differ, both which muſt be firſt found before you can inſcribe the Azimuthes and Almicanters.

Equinoctiall and Polar Plane.

Make the perpendicular ſtile the Radius in all theſe kinds, then ſhall you have three varieties of finding theſe points, firſt in the Equinoctiall plane of the 13 Chapter, wherein the verticall point of the place is diſtant from the foot of the ſtile (being the verticall of the plane) the naturall tangent of the elevation of the pole, which is the inclination of that plane to the Horizon, and the point by which the Horizontall line muſt paſſe, is the naturall tangent of the Complement of the pole, which is the reclination of the plane from the Zenith. But in the polar plane this is quite contrary, ſo is A 3 the Radius in the Diall of the 13 Chapter, and B A 12 a tangent line to it, and C D equall to B C in the diall of the 14 Chapter, H V A a tangent line to it, and A V the naturall tangent of 51 d. 32′. gives the verticall point in the

Equinoctiall; but C H the same tangent gives the horizontall point in the polar; In like manner A H the naturall tangent of 38 d. 28′. gives the horizontall point in the æquinoctiall plane; and C V the same tangent, the verticall point in the polar; thorough H draw a paralell to 7 A 5 in the Equinoctiall, and to 6 C 6 in the polar plane, and that shal be the horizontall line in each; This done make H 3. 1277 the secant of 38 d. 28′. the Radius for the Equinoctiall Diall, and H D 1607 the secant of 51 d. 32′. the Radius for the Polar, then shall the azimuths upon each horizontall line be the naturall tangents of 15 degrees, 30 degrees, 45 degreees, 60 degrees, and 75 degrees (or of any other parts you thinke fit) which being taken of a line divided into ten parts, or of the Sector opened to the length of either Radius, pricke downe both wayes from H in each Horizontall line, and straight lines drawne from each verticall point at N thorough the prickes aforesaid, as are V. 15. V. 30. V. 45. &c. in the Dials of 13 and 14 Chapters, you have the azimuthes required.

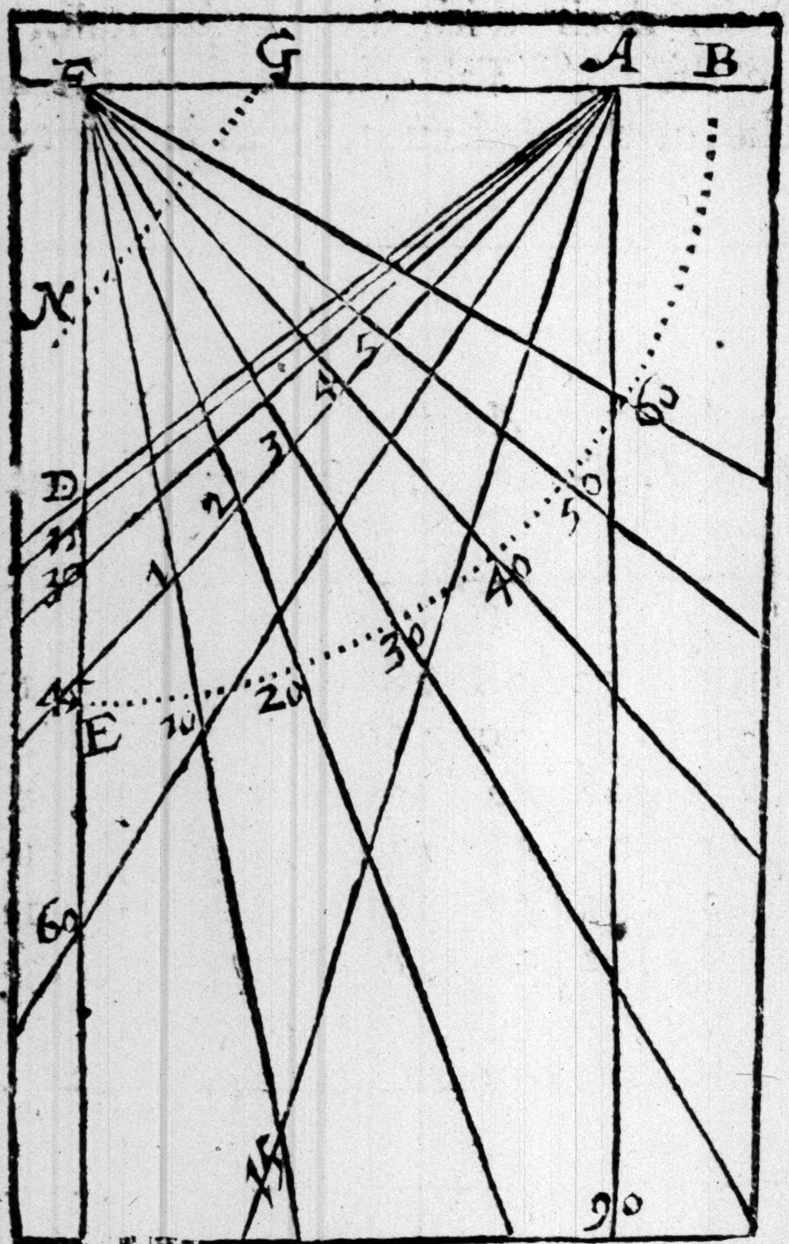
Now make the Diagram adjoyning, wherein let F E be the horizontal line E B the arch of a Quadrant, the lines 10 degrees, 20 degrees, 30 degrees, 40 degrees, &c. the same as afore, and F B crossing F E at right angles as formerly, and further let F A equall to V 3 (of the Diall of the 13 Chapter) and F G equall to V D (in the Diall of the 14 Chapter) representing the axis of the Horizon, be the secant of 51 degrees, 32′. 1607, and F D, F N equall to 3 H, and D H, bee the Secant of the Complement thereof 1277; draw the line A D for the South verticall of this Diall, and G N for the polar, then making

FG for the Polar, and F A the Radius for the Equinoctiall Diall, F D 60 shall bee a tangent line to it; and F D, F 15 degrees, F 45 degrees, and F 60 degrees, &c. shall bee the naturall tangents of the Angles F A D, F A 15 degrees, F A 30 degrees, which are againe (as formerly in the Houre lines) the Complements of the arches of the Table following, under the heighth of the Pole 38 degrees 28′. directly agreeing with the Table of houre lines for the South and North Dials

als, as the Polar doth with the Horizontall, wherefore heere transcribe the same Table in stead of the houre lines, taking the Arches of the Azimuthes, as in this example.

Azimuthes.		*Angles at the Equator.*		*Angles at A.*		*Tangents.*	*Secants.*
d	′	d	′	d	′		
0	0	51	32	38	28	794	1277
15	0	50	34	39	26	822	1295
30	0	47	28	42	32	917	1357
45	0	41	39	48	21	1124	1505
60	0	32	11	57	49	1589	1877
75	0	18	2	71	58	3072	3227

The angle FAD being 38 degrees 28′. take the naturall tangent thereof, 794 (of the line divided, or of the Sector) and set it from F to D. The angle FA 30 being 42 degrees 32′. set the naturall tangent thereof 917 from F to 30. The angle FA 60 being 57 degrees 49′. set the naturall tangent thereof 1589 from F to 60; and so of the rest, straight lines drawne from A thorough these points, shall be the azimuthes crossing the Almicanters of 10. 20. 30. 40. &c. at the same distances from A in this Diagram, that they shall doe from V the verticall point of the Diall, and are easily found by the former rules, because you have the three angles of every Triangle F 5 A, F 4 A, F 3 A, &c. given, *viz.* at A the Complement of the Arch in the Table, at F the Complement of



of the Almicanter, and at 5 the Complement of both to 180d. with the side F A, the axis of the Horizon supposed to be the Radius divided into 10. 100. or 1000 parts, as you thinke fit, wherefore *by the first case of O.P. triangles.*

As the sine of the angle F 5 A 91 *d.* 39′. *is to the line* f A	1000
So is the sine of the angle A F 5 40 *d.* 0′. *to the line* A 5	643

and so of the rest: you may likewise calculate each paire of Almicanters æquidistant from the horizontall line (if it were needfull) at one worke, as you did the paralels of the signes, or all of them together upon each severall Azimuth, by the former rules, as in this example is done for the 45 Azimuth.

The

The angle in the table for 45 d. is	41 *d.* 39'.		*Cosines.*
The Almicanters with the Cosines set by them.	10	0	9993.55
	20	0	9972.98
	30	0	9937.53
	40	0	9884.25
	50	0	9808.07
The Almicanters added to the angle 41 d. 39'. with the Arithmeticall complement of each arch to avoid subtraction	51	39	0105.55
	61	39	0055.48
	71	39	0022.66
	81	39	0004.17
	91	39	0000.17

Logar. of Chil:	*The Almicanters from* A *or* V.	
+ ~~1~~0099.10	1256	10 *d.*
+ ~~1~~0028.46	1068	20
—9960.19	912	30
—9888.87	774	40
—9808.24	643	50
0. *compl char.*		

Now adde the Cosines of 10 d. 20 d. 30 d. &c. to the Arithmeticall Complement of 51 d. 39'. &c. and 61 d. 39'. &c. so have you new Logarithmes, which found in the *Chiliads*, give the lengths of the lines desired, wherefore of a line divided into 10 or 100 parts equal to FA, or of the Sector opened to that width, take the lines 1256 and 1068 and 912 &c. which set from the verticall point V in the Diall of the 13 Chapter, shall give you points in the Azimuth of 45 d. by which the Almicanters of 10 d. 20 d. 30 d. &c. must passe, doe the like with as many other Azimuths as will serve your turne, at last draw all the points of the same denomination into one continued circular line, so shall you have the Almicanters desired. And here againe note for a generall rule, that in this and all the like cases, if any line fall out to be too long, to be set from the Zenith V, you may take that line out of the secant of the angle at A in the table above said.

which

which gives the whole line from the verticall point to the Horizontall line, and set the remainder backe againe upon the Azimuth from the Horizontall line to the Almicanter; so if you set 912 from V to the 30 Almicanter upon the 45 Azimuth: or 593 the remaynder thereof subducted out of 1 505 the secant of 45 d. back from 45 d. in the horizontall line, it will give the same point at a as afore, and so of the rest. Now making F G the radius for the Polar Diall, and using the table proper to the Horizontall, the rest of the worke will differ nothing at all from this.

South and North reclining.

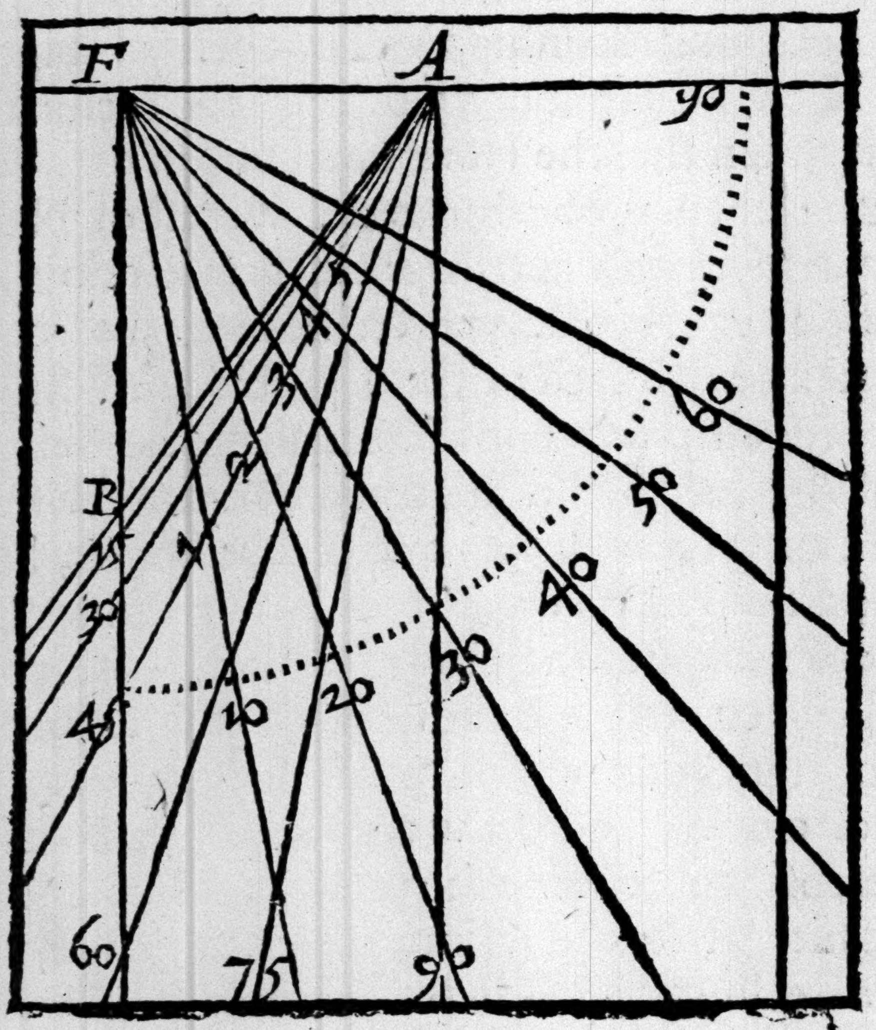
Lastly, in the South and North reclining, the perpendicular stile being Radius, the Meridian is a tangent line thereunto, and the verticall point is the naturall tangent of 65 d. the inclination of the plane to the Horizon, as in the second example of the 13 Chapter, and the Horizontall point is the naturall tangent of 25 d. the reclination thereof from the Zenith, the complement of the former, both which being prickt downe in the Meridian, from the foot of the stile, and the Horizontall line drawne perpendicular thereto, proceed in all respects as formerly.

East and West reclining, South and North declining reclining.

But in the East and West reclining, and South and North declining reclining planes, where the substile, which is the Meridian of the plane, and the 12 of clocke houre, which is the Meridian of the place, are severall lines, you must first draw a perpendicular to the base of the plane thorough the foot of the stile, as is V L H in the Diall of the 12 Chapter, and V K H in the Diall of the 17 Chapter: then making the perpendicular stile L N equall to L S in the one, and K N equall to K F in the other, the radius V L H, and V K H shall be tangent lines to them, and the verticall point V shall be the naturall tangent of 55 d. in the first, and 35 d. in the second, the inclination of each plane to the Ho-

Horizon, and the Horizontall point H ſhall be the naturall tangent of 35 d. in the firſt, and of 55 d. in the ſecond, the reclination of each from the Zenith, which is the complement of the former; the verticall point V in each muſt of neceſſity fall upon the 12 of clocke houre, which is the Meridian of the place, and the Horizontall line drawne by the point H muſt be perpendicular to the lines V L H, and V K H, drawne by the two Zeniths, and paſſe thorough the interſection of the Æquator, and 6 of clock houre, if there be no errour in the worke. Theſe things being found, you muſt proceed in all reſpects as in the former kinds; yet for further ſatisfaction I will give a more particular inſtance in the declining reclining Diall of the 17 Chapter. Next therefore let N H, the ſecant of 55 d. 1743 the reclination of the plane, be radius, then ſhal the Horizontal line H 60 be a tangent line thereunto; open the Sector to the wideſt of N H (or divide a line equall thereto) and from either prick downe the naturall tangents of 15 d. 30 d. 45 d. &c. both wayes from H upon the horizontall line, to each of theſe points draw ſtraight lines from V the verticall point, and theſe ſhall be the Azimuthes deſired, the 30 whereof to the Southwards from H ſhall be coincident with the Meridian or 12 of clocke houre, becauſe the plane doth decline ſo much: and though it had falne out in ſome unequall part of the quadrant (as for the moſt part it doth) yet had the worke beene one and the ſame: Now as in deſcribing the paralels of ſignes you tooke the Subſtile or Meridian of the plane for 12 of clocke, and drew the Horizontall houre lines on each ſide thereof, to facilitate the worke: ſo muſt you alwayes for the Almicanters take the Azimuth perpendicular to the plane (equall to the declination) as in the example is V K H: and on both ſides thereof inſcribe the Azimuths of 15 d. 30 d. 45 d. &c. by which meanes you may make uſe of the ſame table for finding the angles of the Azimuthes at the verticall point, and putting them into the Diagram, as formerly you did the houre lines; for let F A in the Diagram adjoyning, the axis of the Horizon, bee equall to V N in the Diall, which is the ſecant of 35 degrees inclination of the plane to the Horizon, and F B equall to N H, the ſecant of 55 degrees the reclination from the

the Zenith, and complement to the former ; draw the line A B which shall represent the Azimuth V K H perpendicular to the plane, then if you make F A equall to V N the axis of the Horizon, the Radius, F 60 shall bee a tangent line thereunto, and F B, F 15. F 30. F 45. and F 60 &c. shall be the naturall tangents of the Complements of the arches proper to the Azimuthes, under the altitude of the Pole 55 d. equall to the reclination of the plane, which you may collect into a table for further use, as in this example appeareth.



Wherefore divide a line into 10 parts equall to F A, or open the Sector to the length of F A, and pricke downe the severall tangents of this table from F downwards upon the Horizontall line F B 60 : by which draw streight lines from A, so shall you have the azimuthes of 15 d. 30 d. 45 d. 60. d. &c. crossing the Almicanters of 10 d. 20 d. 30 d. 40 d. &c. in this Scheme, at the same

Azimuths.		Angles at the Horizon.		Angle at A		Tangents.	Secants.
d	'	d	'	d	'		1743
0	0	35	0	55	0	1428	1785
15	0	34	4	55	56	1479	1928
30	0	31	14	58	46	1649	2254
45	0	26	20	63	40	2020	3025
60	0	19	18	70	42	2855	5611
75	0	10	16	74	49	5511	

same distances from A, that they will doe from V the verticall point of the Diall. Now have you new triangles here framed as in the former, *viz.* F 5 A, F 4 A, F 3 A, &c. whose angles being given with the side F A, either in knowne parts of an inch, or as Radius, the sides A 5. A 4. A 3. &c. are easily found *by the first Case of O. P. Triangles.* whose distances prickt downe from V the verticall point of the Diall upon the azimuthall lines proper to them, doe give points for the almicanters desired; so shall you find the distances of A 5, A 4, A 3, A 2, and A 1, upon the 45 azimuth to be as in this example.

The angle in the table under the latitude 55 d. for the Azimuth of 45 d. is	26 d.	20'.	*Cosines.*
The Almicanters with their Cosines	10	0	9993.35
	20	0	9972.98
	30	0	9937.53
	40	0	9884.25
	50	0	9808.07
The Almicanters added to the angle 26 d. 20'. with the Arith. Complement of each arch to avoid Subtraction.	36	20	0227.32
	46	20	0140.64
	56	20	0079.73
	66	20	0038.14
	76	20	0012.47

Logar. of Chil:	*Almicanters from A or V.*		
+ 10220.67	1.662	A 1	10 *d.*
+ 10113.62	1.299	A 2	20
+ 10017.26	1.041	A 3	30
— 9922.39	836	A 4	40
— 9820.54	661	A 5	50
o.*comp.char.*			

Adde the Cosine of 10 degrees to the Arithmeticall Complement of 36 d. 20′. and of 20 d. to that of 46 d. 20′, and so of the rest, seeke the new Logarithmes of 0220. 67. &c. in the *Chiliads*, changing the characteriske of 1 into 3 or 4, for more exactnesse sake, so shall you find the distance of A 1 to be 1 662, that is one Radius, and 662 thousand parts of another, which taken of a line divided as aforesaid, or Sector opened to the widest of F A, and set from the verticall point V of the Diall, shall reach to the almicanter of 10 upon the azimuth 45 d. and so of the rest: and note that if there be cause, you may by an arch of a circle draw the same azimuthes in the Diagram on the other side of A 90 also. Lastly, the worke being finished, you may distinguish the azimuths by what numbers you thinke fittest, beginning the accompt either from the 1 verticall as *Clavius* doth, and then the azimuth V K H perpendicular to the plane, shall be the 60. or from the Meridian, and then it shall be the 30, or from it selfe (as in this example is done for imitation sake) and then the East azimuth shall be the 60, and the South verticall the 30 from thence, as much as the plane it selfe declineth.

CHAP.

CHAP. XXXIII.

How to deſcribe the circles of poſition upon theſe Planes.

THe circles of poſition are great circles of the Sphere, croſſing each other in the common interſection of the Meridian and Horizon, and reckoned (according to moſt authentike authors) upon the Equinoctiall, both wayes from the Meridian downe to the Horizon; the uſe of them (perticularly of thoſe of 30 d. and 60 d. diſtant each wayes from the Meridian) is chiefly for ſuch as are aſtrologically given, to ſhew them at all times of the day, in which of the 12 parts (commonly called the *houſes of Heaven*) the Sun is commorant, but they doe alſo repreſent (conſidered upon the firſt verticall) the planes of every Eaſt and Weſt reclining or inclining Diall, as hath beene ſaid in the 12 Chapter aforeſaid, whereof divers other uſes might be made.

By the definition it appeares, that they are great circles, and therefore become ſtraight lines, being projected upon the plane, and they are ſometimes paralels, ſometimes they meet at equall, and ſometimes at unequall angles, according as the planes on which they are projected, are paralell, right, or oblique, to the axis of the prime verticall, in whoſe Poles they are ~~omitted~~ united.

Horizontall, Eaſt and Weſt direct, and Eaſt and Weſt reclining.

In the horizontall, the Eaſt and Weſt direct, and Eaſt and Weſt reclining, theſe circles are all paralels; the reaſon is manifeſt, for as the houre lines of all ſuch planes, as lie in any houre circle, are therefore paralels each to other, becauſe the planes themſelves cut not the axis of the World, but are paralell thereto; ſo is it in the *Circles* of *Poſitien*, ſo oft as

their planes have the ſame ſituation to the axis of the prime verticall, in whoſe Poles they meet.

In a right ſphere, the Equinoctiall plane lyeth in the houre circle of 6, and in the Horizon, paralell to the axis of the world, ſo doth the 90 circle of poſition (which according to Aſtrologers is the firſt and ſeventh houſe of heaven) in an oblique ſphere, lie in the Horizon, paralell to the axis of the prime verticall.

In East and Weſt Dials, the plane lyeth in the Meridian or houre circle of 12, which is alſo the firſt circle of poſition, preſcribing the tenth and fourth houſe of heaven. In declining reclining to the pole the plane may happen upon any other houre circle or part, and ſo in Eaſt and Weſt reclining, the plane may fall upon any other circle of poſition, from which agreement it is evident, that as the houre lines in the firſt ſort, ſo the circles of poſition in the ſecond, are evermore paralels each to other.

In the horizontall, they are thus eaſily inſcribed: make FD of the Diall fol. 91. 1607 the ſecant of 51 d. 32′. the elevation of the pole, the radius, then is ♈ F ♎ the Æquator a tangent line thereunto, and the naturall tangents of 577 for 30 d. and 1732 for 60 d. ſet each way upon the Equinoctiall from F, are the points of 11. 12. 9. and 8. houſes of heaven, thorough which draw paralels to the Meridian or houre of 12, as are IX and VIII the prickt lines in the Horizontall, and you have your deſire.

In the Eaſt and Weſt, let LO 1277 the ſecant of 38 d. 38′. the complement of the elevation of the pole, be the Radius, then ſhall the Æquator KDE be a tangent line thereunto, and the naturall tangents of 577 for 30 d. and of 1732 for 60 d. ſet downwards upon the Equinoctiall line from A to m and h, are the points of the 30 and 60 circle of poſition, thorough which points draw paralels to the horizontall line, as are xii and xi in the Diall of the ninth Chapter, ſo have you your deſire.

In Eaſt and Weſt reclining, let SR 1119 the ſecant of 26 d. 41′ the heighth of the pole above the plane, in the Diall of the 12 Chapter, be Radius then ſhall the Æquator be a tangent line thereto, and the naturall tangent of 577 for 30 d. and 1732 for 60 d. ſet each wayes upon the Equinoctiall line from the point R of the ſubſtile, afford you pricks, by which draw paralels, either

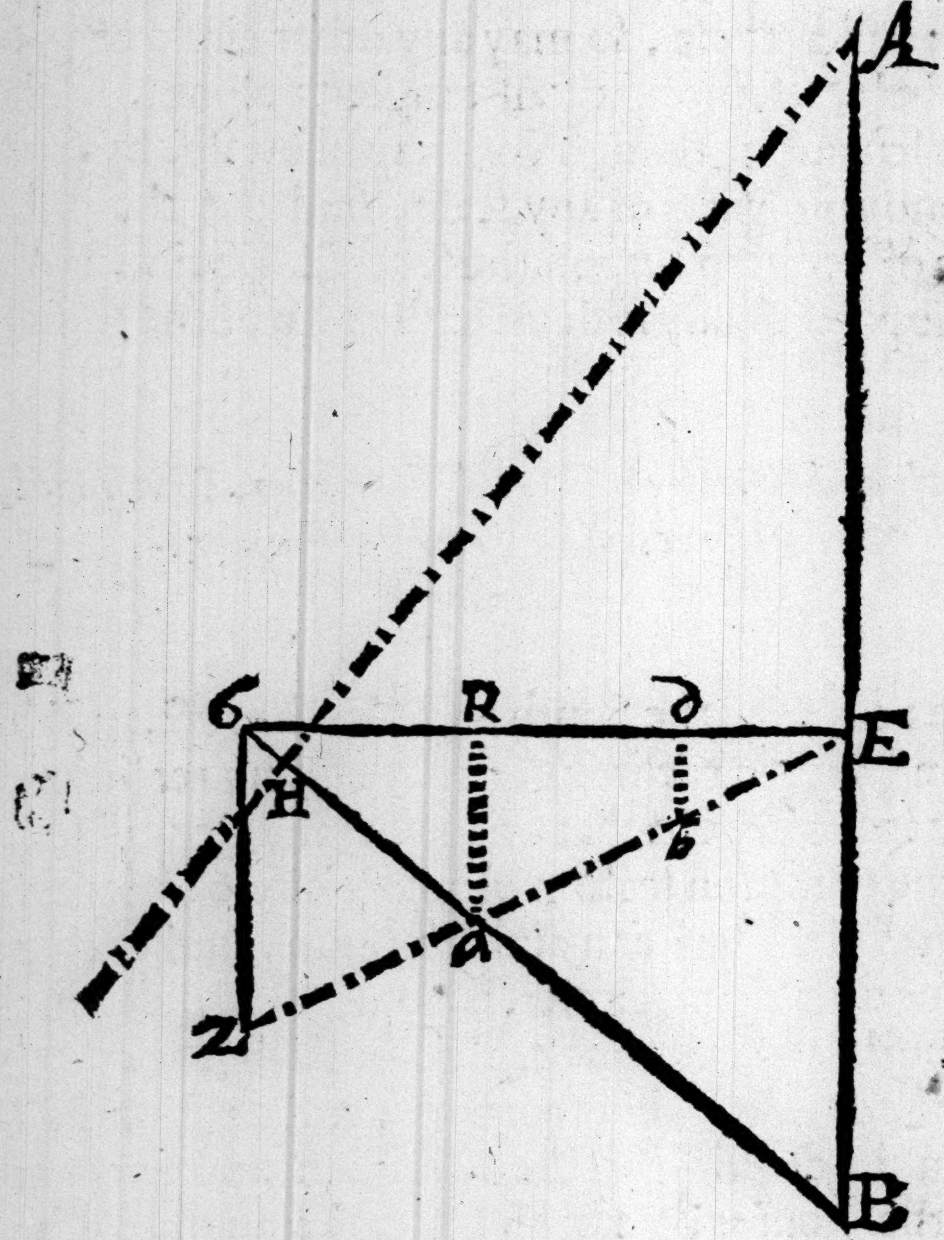
ther to the horizontall, or Meridian line of the Diall, so have you your desire: and as these, so may any other circle of position be inserted by helpe of the naturall tangents alone, without any trouble of calculation, though you may likewise, by giving each Radius in knowne parts of any scale, find out the distances of these circles of position, upon the severall Equinoctiall lines in like knowne parts of any scale: as hath often beene shewed heretofore.

South and North erect, and declining, South and North reclining, and declining reclining.

In all the rest, *viz.* the South and North erect, and declining, the South and North reclining, and declining reclining, J might particularly instance, but that one generall rule will serve for all: for seeing the common section of every circle of position, is the intersection of the Meridian and Horizon, and each particular section of the domifying circles, is 30 d. & 60 d. distant from the Meridian, both wayes upon the Equinoctiall; draw but straight lines from the point of their common intersection in the Diall (which is in the crossing of the Meridian and horizontall line) thorough the houres of 10 and 8. and 2 and 4 in the Equinoctial, which are alwayes 30 d. & 60 d. distant from the Meridian, and you have your desire.

But if the Diall want a center, as in the example of the eleventh Chapter it doth, then is the Meridian also wanting, whose intersection with the horizontall line should helpe you; in which case you may find two other points, one in the prime verticall, and another in a paralell thereto, so shall you have three points, (these in the Equinoctiall at 10 and 8 remayning certaine) by which to draw each circle of position, without respect to the intersection of the Meridian and Horizon, though being continued beyond the plane, they will also meet therein.

In the Diagram adjoyning, let A E B be the Meridian, 6 R D E the horizontall line, A H the substile, 6 H a B the Equinoctiall, E b a Z the circle of position, 6 Z the prime verticall, R a and d b



two paralels thereunto, in which I seeke points to draw the circle of position by; and note, that though for demonstration sake I instance in this small Diagram, yet hath the operations reference to the Diall of the 11 Chapter, wherein let H O be the Radius, then shall 6 H be the naturall tangent of 5 degrees 0087, and H B the naturall tangent of 85 degrees. 11403 which added together, give the whole length of the Equinoctiall line 6 a B 11517 from 6 of clock to the Meridian, by that line, and the angle at B 51 d. 40′. the complement of H A E, you may find 6 E to be 9034. *by the first Case of R. P. triangles.* For

As the sine of 6 E B. 90 *d.* 0′. *is to the line* 6 B 11517.

So is the sine of 6 B E 51 *d.* 40′. *to the line* 6 E 9034.

Then

Then raise a perpendicular from a (the intersection of 10 of clock upon the Equinoctiall) to the Horizontall line at R, which is 60 d. distant from the houre of 6, the naturall tangent of 6 H. 5 d. 0087 and of H a 55 d. 1428, added together, give the line 6 H a, 1515, by which and the same angle at a of 51 d. 40′. (because R a and E B are paralels) you may find, *by the former case*, the line 6 R to be 1188, and the angle R 6 a 38 d. 20′. and R a to be 940 next hand.

For as the sine of 6 R a 90 d. 0′. is to the line 6 a 1515. so is the sine of 6 a R 51 d. 40′. to the line 6 R 1188, and so is the sine of the angle a 6 R 38 d. 28′. to the line R a. 940.

Take 6 R 1188 out of 6 E 9034, there resteth R E 7846, then againe *by the* 45 *of the first of Pitiscus,* as the line E R 7846 is to the line R a 940. so is the line E 6 9034 to the line 6 Z 1082, set 1082 from 6 downwards upon the prime verticall, so have you the point Z and a to direct you; if you will find another point betweene a and the Meridian, take any convenient part that you will for your purpose out of the line 9034 suppose 2500, that is twice the Radius and a halfe, there will remayne d E 6534: set 2500 from 6 to d, and let fall the perpendicular d b, then againe by the former rule.

As the line E 6 9034 *is to the line* 6 Z 1082.
So is the line e d 6534 *to the line* d b 783,

set 783 from d to b, the third point shall be at b to draw the circle of position E b a z, without the helpe of the intersection of the Meridian and Horizontall line at E, which falleth not upon the plane at all.

And thus must you worke in all respects for the other circle of position passing by the eighth of clocke houre.

The particular operations are as followeth.

						Logar.
				Tang. As the sine of 6 E B	90 *d.* 0′.	10000.00
1	6 H.	5 *d.* 0′.	087	*is to* 6 B	11517	1061.34
	H B	85	0.11430	*so is the sine* 6 B E	51 40	9894.55
	6 H B		11517	*to* 6 E	9034	10955.89

			Tang.			Logar.
2	6H	5 d. 0'.	087	*As the sine of* 6Ra	90 d. 0'.	+10000.00
	Ha	55	0 1428	*To* 6a	1515	+0180.41
	6Ha		1515	*So the sine of* baR	51 40	9894.55
				And so the sine of abR	38 20	9792.56
				To 6R	1188	+10074.96
				And to Ra	940	—19972.97
						0.*cha.cōp.*

				parts	Logar.
3	6E	9034	*As* RE	7846	+0894.65
	6R	1188	*To* Ra	940	—0027.03
	RE	7846	*So* E6	9034	+0955.89
			To 6Z	1082	+0034.21

4	6e	9034	*As* e6	9034	+9044.10. *Arith. Comple.*
	6d	2500	*To* 6Z	1082	+0034.21
	de	6534	*So* ed	6534	+0815.18
			To db	783	—9893.49
					0. *compl. charact.*

A Table for the Almicanters proper to the Diall of the eleventh Chapter.

Almicant.	Naturall Tangents			
d		*Radius for the 20 Azimuth to the North is the secant*	*Radius for the first Azimuth the secant*	*Radius for the 20 Azimuth to the Southward the secant*
10	176			
20	364			
30	577			
40	839			
50	1192	1116	1006	1029

Radius for the 40 Azimuth the secant	*Radius for the 60 Azimuth the secant*	*Radius for the 70 Azimuth the secant*
1201	1886	2250

This

This Table following giveth the angles, which the houre lines make with the Equinoctiall upon the Trigon, as in the 27 Chapter, and also which the Azimuths make with the Horizon, as in the 31 Chapter, and is calculated of purpose, to facilitate the worke in describing the paralels of the Signes, Diurnall Arches, and Almicanters upon each severall plane. The Canon to make, it is this, *by the first or second of the second Case of R. S. Triangles.*

As the Radius.
Is to the Cosine of the houres distance from the Meridian,
So is the Cotangent of the elevation of the Pole,
To the tangent of the arch for that houres distance.

Example for 2 or 10 of clocke in the latitude 9 d. 20′.

			Logar.
At the sine of	90 d.	0′	10000.00
Is to the Cosine of	30	0	9937.53
So is the cotangent of	9	20	10784.22
To the tangent of	79	15	10721.75

By the same rule this Table might be continued to parts of houres also, which would be usefull for divers other purposes.

Houres

Houres		12		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
0	0	90	0	90	0	0	0	90	0	0	0
	5	89	55	89	55	0	5	89	54	0	6
	10		50		50	0	10		48	0	12
	15		45		44	0	16		43	0	17
	20		40		39	0	21		37	0	23
	25		35		34	0	26		31	0	29
	30		30		29	0	31		25	0	35
	35		25		24	0	36		20	0	40
	40		20		19	0	41		14	0	46
	45		15		13	0	47		8	0	52
	50		10		8	0	52		2	0	58
	55		5		3	0	57	88	56	1	4
1	0		0	88	58	1	2		51	1	9
	5	88	55		53	1	7		45	1	15
	10		50		48	1	12		39	1	21
	15		45		42	1	18		33	1	27
	20		40		37	1	23		28	1	32
	25		35		32	1	28		22	1	38
	30		30		27	1	33		16	1	44
	35		25		22	1	38		10	1	50
	40		20		16	1	44		5	1	55
	45		15		11	1	49	87	59	2	1
	50		10		6	1	54		53	2	7
	55		5		1	1	59		47	2	13
2	0		0	87	56	2	4		41	2	19
	5	87	55		51	2	9		36	2	24
	10		50		45	2	15		30	2	30
	15		45		40	2	20		24	2	36
	20		40		35	2	25		18	2	42
	25		35		30	2	30		13	2	47
	30		30		25	2	35		7	2	53
	35		25		20	2	40		1	2	59
	40		20		14	2	46	86	55	3	5
	45		15		9	2	51		50	3	10
	50		10		4	2	56		44	3	16
	55		5	86	50	2	1		38	3	22
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres.	3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.	G.	M.	G.	M.	G.	M.	G.	M.	G,	M.	G.	M.
0 0	90	00	0	0	90	0	0	0	90	0	0	0
5	89	53	0	7	89	50	0	10	89	41	0	19
10		46	0	14		40	0	20		21	0	39
15		39	0	21		30	0	30		2	0	58
20		32	0	28		20	0	40	88	43	1	17
25		25	0	35		10	0	50		23	1	37
30		18	0	42		0	0	0		4	1	56
35		10	0	50	88	50	1	10	87	45	2	15
40		3	0	57		40	1	20		26	2	34
45	88	56	1	4		30	1	30		6	2	54
50		49	1	11		20	1	40	86	47	3	13
55		42	1	18		10	1	50		28	3	32
1 0		35	1	25		0	2	0		9	3	51
5		28	1	32	87	50	2	10	85	49	4	11
10		21	1	39		40	2	20		30	4	30
15		14	1	46		30	2	30		11	4	49
20		7	1	53		20	2	40	84	52	5	8
25		0	2	0		10	2	50		33	5	27
30	87	53	2	7		0	2	0		13	5	47
35		46	2	14	86	50	3	10	83	54	6	6
40		39	2	21		40	3	20		35	6	25
45		32	2	28		30	3	30		16	6	44
50		24	2	36		20	3	40	82	57	7	3
55		17	2	43		10	3	50		38	7	22
2 0		10	2	50		0	4	0		19	7	41
5		3	2	57	85	50	4	10		0	8	0
10	86	56	3	4		40	4	20	81	41	8	19
15		49	3	11		30	4	30		22	8	38
20		42	3	18		20	4	40		3	8	57
25		35	3	25		11	4	49	80	44	9	16
30		28	3	32		1	4	59		25	9	35
35		21	3	39	84	51	5	9		7	9	53
40		14	3	46		41	5	19	79	48	10	12
45		7	3	53		31	5	29		29	10	31
50	86	0	4	0		21	5	39		10	10	50
55		53	4	7		11	5	49	78	52	11	8
Azimuths	45 *d*.0'.				60 *d*.0'.				75 *d*.0'.			

Houres Latit.		12. G. M.	1. 11. G.	M.	Compl. G.	M.	2. 10. G.	M.	Compl. G.	M.
3	0	87 0	86	54	3	6	86	32	3	28
	5	86.55		48	3	12		26	3	34
	10	50		43	3	17		21	3	39
	15	45		38	3	22		15	3	45
	20	40		33	3	27		9	3	51
	25	35		28	3	32		3	3	57
	30	30		23	3	37	85	58	4	2
	35	25		17	3	43		52	4	8
	40	20		12	3	48		46	4	14
	45	15		7	3	53		40	4	20
	50	10		2	3	58		35	4	25
	55	5	85	57	4	3		29	4	31
4	0	0		52	4	8		23	4	37
	5	85.55		46	4	14		17	4	43
	10	50		41	4	19		11	4	49
	15	45		36	4	24		6	4	54
	20	40		31	4	29		0	5	0
	25	35		26	4	34	84	54	5	6
	30	30		21	4	39		48	5	12
	35	25		15	4	45		43	5	17
	40	20		10	4	50		37	5	23
	45	15		5	4	55		31	5	29
	50	10		0	5	0		25	5	35
	55	5	84	55	5	5		20	5	40
5	0	0		49	5	11		14	5	46
	5	84.55		34	5	16		8	5	52
	10	50		39	5	21		2	5	58
	15	45		34	5	26	83	57	6	3
	20	40		29	5	31		51	6	9
	25	35		24	5	36		45	6	15
	30	30		18	5	42		39	6	21
	35	25		13	5	47		34	6	26
	40	20		8	5	52		28	6	32
	45	15		3	5	57		22	6	38
	50	10	83	58	6	2		16	6	44
	55	5		53	6	7		11	6	49
Azimuths			15 *d.* 0.				30 *d.* 0.			

Houres		3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.		G.	M	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
3	0	85	46	4	14	84	1	5	59	78	33	11	27
	5		39	4	21	83	51	6	9		15	11	45
	10		32	4	28		41	6	19	77	56	12	4
	15		25	4	35		31	6	29		38	12	22
	20		17	4	43		21	6	39		19	12	41
	25		10	4	50		11	6	49		1	12	59
	30		3	4	57		2	6	58	76	42	13	18
	35	84	56	5	4	82	52	7	8		24	13	36
	40		49	5	11		42	7	18		6	13	54
	45		42	5	18		32	7	28	75	47	14	13
	50		35	5	25		22	7	38		29	14	31
	55		28	5	32		12	7	48		11	14	49
4	0		21	5	39		2	7	58	74	53	15	7
	5		14	5	46	81	52	8	8		35	15	25
	10		7	5	53		43	8	17		17	15	43
	15		0	6	0		33	8	27	73	59	16	1
	20	83	53	6	7		23	8	37		41	16	19
	25		46	6	14		13	8	47		23	16	37
	30		39	6	21		3	8	57		5	16	55
	35		32	6	28	80	53	9	7	72	47	17	13
	40		24	6	35		44	9	16		30	17	30
	45		18	6	42		34	9	26		12	17	48
	50		11	6	49		24	9	36	71	54	18	6
	55		4	6	56		14	9	46		37	18	23
5	0	82	57	7	3		4	9	56		19	18	41
	5		50	7	10	79	55	10	5		2	18	58
	10		43	7	17		45	10.15		70	45	19	15
	15		36	7	24		35	10.25			27	19	33
	20		29	7	31		25	10.35			10	19	50
	25		22	7	38		16	10.44		69	53	20	7
	30		15	7	45		6	10.54			36	20	24
	35		8	7	52	78	56	11	4		18	20	42
	40		1	7	59		47	11.13			1	20	59
	45	81	54	8	6		37	11.23		68	44	21	16
	50		47	8	13		27	11.33			28	21	32
	55		40	8	30		17	11.43			11	21	49

Azimuths. 45 *d*.0'. 60 *d*.0'. 75 *d*.0'.

Houres		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
6	0	84	0	83	47	6	13	83	5	6	55
	5	83	55		42	6	18	82	59	7	1
	10		50		37	6	23		53	7	7
	15		45		32	6	28		48	7	12
	20		40		27	6	33		42	7	18
	25		35		22	6	38		36	7	24
	30		30		16	6	44		30	7	30
	35		25		11	6	49		25	7	35
	40		20		6	6	54		19	7	41
	45		15		1	6	59		13	7	47
	50		10	82	56	7	4		7	7	53
	55		5		51	7	9		2	7	58
7	0		0		45	7	15	81	56	8	4
	5	82	55		40	7	20		50	8	10
	10		50		35	7	25		44	8	16
	15		45		30	7	30		39	8	21
	20		40		25	7	35		33	8	27
	25		35		19	7	41		27	8	33
	30		30		14	7	46		21	8	39
	35		25		9	7	51		16	8	44
	40		20		4	7	56		10	8	50
	45		15	81	59	8	1		4	8	56
	50		10		54	8	6	80	58	9	2
	55		5		48	8	12		53	9	7
8	0		0		43	8	17		47	9	13
	5	81	55		38	8	22		41	9	19
	10		50		33	8	27		35	9	25
	15		45		28	8	32		30	9	30
	20		40		23	8	37		24	9	36
	25		35		17	8	43		18	9	42
	30		30		12	8	48		13	9	47
	35		25		7	8	53		7	9	53
	40		20		2	8	58		1	9	59
	45		15	80	57	9	3	79	55	10	5
	50		10		52	9	8		50	10	10
	55		5		46	9	14		44	10	16
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
6	0	81	33	8	27	78	8	11	52	67	54	22	6
	5		26	8	34	77	58	12	2		37	22	23
	10		19	8	41		48	12	12		20	22	40
	15		12	8	48		39	12	21		4	22	56
	20		5	8	55		29	12	31	66	47	23	13
	25	80	58	9	2		19	12	41		31	23	29
	30		51	9	9		10	12	50		14	23	46
	35		44	9	16		0	13	0	65	58	24	2
	40		37	9	23	76	51	13	9		42	24	18
	45		30	9	30		41	13	19		26	24	34
	50		23	9	37		31	13	29		9	24	51
	55		16	9	44		22	13	38	64	53	25	7
7	0		9	9	51		12	13	48		37	25	23
	5		2	9	58		3	13	57		21	25	39
	10	79	55	10	5	75	53	14	7		5	25	55
	15		48	10	12		43	14	17	63	49	26	11
	20		41	10	19		34	14	26		34	26	26
	25		34	10	26		24	14	36		18	26	42
	30		27	10	33		15	14	45		2	26	58
	35		20	10	40		5	14	55	62	47	27	13
	40		13	10	47	74	56	15	4		31	27	29
	45		6	10	54		46	15	14		16	27	44
	50	78	59	11	1		37	15	23		0	27	0
	55		52	11	8		27	15	33	61	45	28	15
8	0		46	11	14		18	15	42		30	28	30
	5		39	11	21		9	15	51		15	28	45
	10		32	11	28	73	59	16	1		0	29	0
	15		25	11	35		50	16	10	60	45	29	15
	20		18	11	42		40	16	20		30	29	30
	25		11	11	49		31	16	29		15	29	45
	30		4	11	56		22	16	38		0	29	0
	35	77	57	12	3		12	16	48	59	45	30	15
	40		50	12	10		3	16	57		30	30	30
	45		43	12	17	72	53	17	7		16	30	44
	50		36	12	24		44	17	16		1	30	59
	55		29	12	31		35	17	25	58	47	31	13
Azimuths. 45 *d.* 0'.						60 *d.* 0'.				75 *d.* 0'.			

Houres		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
9	0	81	0	80	41	9	19	79	38	10	22
	5	80	55		36	9	24		32	10	28
	10		50		31	9	29		27	10	33
	15		45		26	9	34		21	10	39
	20		40		21	9	39		15	10	45
	25		35		15	9	45		10	10	50
	30		30		10	9	50		4	10	56
	35		25		5	9	55	78	58	11	2
	40		20		0	10	0		52	11	8
	45		15	79	55	10	5		47	11	13
	50		10		50	10	10		41	11	19
	55		5		44	10	16		35	11	25
10	0		0		39	10	21		29	11	31
	5	79	55		34	10	26		24	11	36
	10		50		29	10	31		18	11	42
	15		45		24	10	36		12	11	48
	20		40		19	10	41		7	11	53
	25		35		13	10	47		1	11	59
	30		30		8	10	52	77	55	12	5
	35		25		3	10	57		49	12	11
	40		20	78	58	11	2		44	12	16
	45		15		53	11	7		38	12	22
	50		10		48	11	12		32	12	28
	55		5		42	11	18		27	12	33
11	0	79	0		37	11	23		21	12	39
	5	78	55		32	11	28		15	12	45
	10		50		27	11	33		10	12	50
	15		45		22	11	38		4	12	56
	20		40		17	11	43	76	58	13	2
	25		35		11	11	49		52	13	8
	30		30		6	11	54		47	13	13
	35		25		1	11	59		41	13	19
	40		20	77	56	12	4		35	13	25
	45		15		51	12	9		30	13	30
	50		10		46	12	14		24	13	36
	55		5		41	12	19		18	13	42
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres.		3. 9.		*Compl.*		4. 8.		*Compl.*		5. 7.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
9	0	77	22	12	38	72	25	17	35	58	32	31	28
	5		16	12	44		16	17	44		18	31	42
	10		9	12	51		7	17	53		3	31	57
	15		2	12	58	71	58	18	2	57	49	32	11
	20	76	55	13	5		48	18	12		35	32	25
	25		48	13	12		39	18	21		21	32	39
	30		41	13	19		30	18	30		7	32	53
	35		34	13	26		20	18	40	56	53	33	7
	40		27	13	33		11	18	49		39	33	21
	45		20	13	40		2	18	58		25	33	35
	50		14	13	46	70	53	19	7		11	33	49
	55		7	13	53		44	19	16	55	58	34	2
10	0		0	14	0		34	19	26		44	34	16
	5	75	53	14	7		25	19	35		31	34	29
	10		46	14	14		16	19	44		17	34	43
	15		39	14	21		7	19	53		4	34	56
	20		32	14	28	69	58	20	2	54	50	35	10
	25		26	14	34		49	20	11		37	35	23
	30		19	14	41		40	20	20		24	35	36
	35		12	14	48		31	20	29		10	35	50
	40		5	14	55		22	20	38	53	57	36	3
	45	74	58	15	2		12	20	48		44	36	16
	50		51	15	9		3	20	57		31	36	29
	55		45	15	15	68	54	21	6		18	36	42
11	0		38	15	22		45	21	15		6	36	54
	5		31	15	29		36	21	24	52	53	37	7
	10		24	15	36		27	21	33		40	37	20
	15		17	15	43		18	21	42		27	37	33
	20		10	15	50		9	21	51		15	37	45
	25		4	15	56		0	21	0		2	37	58
	30	73	57	16	3	67	52	22	8	51	50	38	10
	35		50	16	10		43	22	17		37	38	23
	40		43	16	17		34	22	26		25	38	35
	45		36	16	24		25	22	35		13	38	47
	50		30	16	30		16	22	44		1	38	59
	55		23	16	37		7	22	53	50	48	39	12

Azimuths 45 *d.* 0'.   60 *d.* 0'.   75 *d.* 0'.

Houres		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
12	0	78	0	77	35	12	25	76	13	13	47
	5	77	55		30	12	30		7	13	53
	10		50		25	12	35		1	13	59
	15		45		20	12	40	75	56	14	4
	20		40		15	12	45		50	14	10
	25		35		10	12	50		44	14	16
	30		30		4	12	56		38	14	22
	35		25	76	59	13	01		33	14	27
	40		20		54	13	06		27	14	33
	45		15		49	13	11		21	14	39
	50		10		44	13	16		16	14	44
	55		5		39	13	21		10	14	50
13	0		0		33	13	27		4	14	56
	5	76	55		28	13	32	74	59	15	01
	10		50		23	13	37		53	15	07
	15		45		18	13	42		47	15	13
	20		40		13	13	47		42	15	18
	25		35		8	13	52		36	15	24
	30		30		3	13	57		30	15	30
	35		25	75	57	14	03		25	15	35
	40		20		52	14	08		19	15	41
	45		15		47	14	13		13	15	47
	50		10		42	14	18		8	15	52
	55		5		37	14	23		2	15	58
14	0		0		32	14	28	73	56	16	04
	5	75	55		26	14	34		51	16	09
	10		50		21	14	39		45	16	15
	15		45		16	14	44		39	16	21
	20		40		11	14	49		34	16	26
	25		35		6	14	54		28	16	32
	30		30		1	14	59		22	16	38
	35		25	74	56	15	04		17	16	43
	40		20		50	15	10		11	16	49
	45		15		45	15	15		5	16	55
	50		10		40	15	20		0	17	00
	55		5		34	15	25	72	54	17	06
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
12	0	73	16	16	44	66.	58	23	2	50	36	39	24
	5		9	16	51		49	23	11		24	39	36
	10		3	16	57		40	23	20		12	39	48
	15	72	56	17	4		32	23	28		0	40	0
	20		49	17	11		23	23	37	49	49	40	11
	25		42	17	18		14	23	46		37	40	23
	30		36	17	24		5	23	55		25	40	35
	35		29	17	31	65	57	24	03		13	40	47
	40		22	17	38		48	24	12		2	40	58
	45		15	17	45		39	24	21	48	50	41	10
	50		9	17	51		30	24	30		39	41	21
	55		2	17	58		21	24	38		27	41	33
13	0	71	55	18	05		13	24	47		16	41	44
	5		48	18	12		4	24	56		5	41	55
	10		42	18	18	64	56	25	04	47	53	42	7
	15		35	18	25		47	25	13		42	42	18
	20		28	18	32		38	25	22		31	42	29
	25		21	18	38		30	25	30		20	42	40
	30		15	18	45		21	25	39		9	42	51
	35		8	18	52		13	25	47	46	58	43	2
	40		1	18	59		4	25	56		47	43	13
	45	70	55	19	05	63	55	26	05		36	43	24
	50		48	19	12		47	26	13		27	43	34
	55		41	19	19		38	26	22		15	43	45
14	0		35	19	25		30	26	30		4	43	56
	5		28	19	32		21	26	39	45	54	44	6
	10		21	19	39		13	26	47		43	44	17
	15		15	19	45		4	26	56		33	44	27
	20		8	19	52	62	56	27	04		22	44	38
	25		1	19	59		47	27	13		12	44	48
	30	69	55	20	05		39	27	21		1	44	59
	35		48	20	12		31	27	29	44	51	45	9
	40		41	20	19		22	27	38		41	45	19
	45		35	20	25		14	27	46		31	45	29
	50		28	20	32		5	27	54		21	45	39
	55		21	20	39	61	57	28	03		10	45	49

Azimuths. 45 *d*. 0'. 60 *d*. 0'. 75 *d* 0'.

Houres		12.		1.	11.	*Compl.*		2.	10.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
15	0	75	0	74	30	15	30	27	48	17	12
	5	74	55		25	15	35		43	17	17
	10		50		19	15	41		37	17	23
	15		45		14	15	46		32	17	29
	20		40		9	15	51		26	17	34
	25		35		4	15	56		20	17	40
	30		30	73	59	16	01		15	17	45
	35		25		54	16	06		9	17	51
	40		20		49	16	11		3	17	57
	45		15		43	16	17	71	58	18	02
	50		10		38	16	22		52	18	08
	55		5		33	16	27		46	18	14
16	0		0		28	16	32		41	18	19
	5	73	55		23	16	37		35	18	25
	10		50		18	16	42		30	18	30
	15		45		13	16	47		24	18	36
	20		40		7	16	53		18	18	42
	25		35		2	16	58		13	18	47
	30		30	72	57	17	03		7	18	53
	35		25		52	17	08		1	18	59
	40		20		47	17	13	70	56	19	04
	45		15		42	17	18		50	19	10
	50		10		36	17	24		45	19	15
	55		5		31	17	29		39	19	21
17	0		0		26	17	34		34	19	27
	5	72	55		21	17	39		28	19	32
	10		50		16	17	44		22	19	38
	15		45		11	17	49		16	19	43
	20		40		6	17	54		11	19	49
	25		35		0	18	0		5	19	55
	30		30	71	55	18	05		0	20	00
	35		25		50	18	10	69	54	20	06
	40		20		45	18	15		48	20	12
	45		15		40	18	20		43	20	17
	50		10		35	18	25		37	20	23
	55		5		30	18	30		32	20	28
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
15	0	69	15	20	45	61	49	28	11	44	0	46	0
	5		8	20	52		41	28	19	43	50	46	9
	10		2	20	58		32	28	28		41	46	19
	15	68	55	21	05		24	28	36		31	46	29
	20		48	21	12		16	28	44		21	46	39
	25		42	21	18		7	28	53		11	46	49
	30		35	21	25	60	59	29	01		1	46	59
	35		29	21	32		51	29	09	42	52	47	8
	40		22	21	38		43	29	17		42	47	18
	45		15	21	45		34	29	26		33	47	27
	50		9	21	51		26	29	34		23	47	37
	55		2	21	58		18	29	42		14	47	46
16	0	67	56	22	04		10	29	50		4	47	56
	5		49	22	11		2	29	58	41	55	48	5
	10		42	22	18	59	54	30	06		46	48	14
	15		36	22	24		46	30	14		36	48	24
	20		29	22	31		38	30	22		27	48	33
	25		23	22	37		29	30	31		18	48	42
	30		16	22	44		21	30	39		9	48	51
	35		10	22	50		13	30	47		0	49	0
	40		3	22	57		5	30	55	40	51	49	9
	45	66	57	23	03	58	57	31	03		42	49	18
	50		50	23	10		49	31	11		33	49	27
	55		44	23	16		41	31	19		24	49	36
17	0		37	23	23		33	31	27		15	49	45
	5		31	23	29		25	31	35		6	49	54
	10		24	23	36		17	31	43	39	57	50	3
	15		18	23	42		10	31	50		49	50	11
	20		11	23	49		2	31	58		40	50	20
	25		5	23	55	57	54	31	06		31	50	29
	30	65	58	24	02		46	32	14		2	50	37
	35		52	24	08		38	32	22		14	50	46
	40		45	24	15		30	32	30		6	50	54
	45		39	24	21		22	32	38	38	57	51	3
	50		32	24	28		15	32	45		49	51	11
	55		26	24	34		7	32	53		41	51	19
Azimuths. 45 *d.* 0'.						60 *d.* 0'.				75 *d.* 0'.			

Houres Latit.		12. G.	M.	1. 11. G.	M.	Compl. G.	M.	2. 10. G.	M.	Compl. G.	M.
18	0	71	0	71	24	18	36	69	26	20	34
	5	71	55		19	18	41		20	20	40
	10		50		14	18	46		15	20	45
	15		45		9	18	51		9	20	51
	20		40		4	18	56		4	20	56
	25		35	70	59	19	01	68	58	21	02
	30		30		54	19	06		53	21	07
	35		25		48	19	11		47	21	13
	40		20		43	19	17		41	21	19
	45		15		38	19	22		36	21	24
	50		10		33	19	27		30	21	30
	55		5		28	19	32		25	21	35
19	0		0		23	19	37		19	21	41
	5	70	55		18	19	42		13	21	47
	10		50		13	19	47		8	21	52
	15		45		7	19	53		2	21	58
	20		40		2	19	58	67	57	22	03
	25		35	69	57	20	03		51	22	09
	30		30		52	20	08		46	22	14
	35		25		46	20	13		40	22	20
	40		20		42	20	18		34	22	26
	45		15		37	20	23		29	22	31
	50		10		31	20	29		23	22	37
	55		5		26	20	34		18	22	42
20	0		0		21	20	39		12	22	48
	5	69	55		16	20	44		7	22	53
	10		50		11	20	49		1	22	59
	15		45		6	20	54	66	56	23	04
	20		40		1	20	59		50	23	10
	25		35	68	56	21	04		45	23	15
	30		30		50	21	10		39	23	21
	35		25		45	21	15		33	23	27
	40		20		40	21	20		28	23	32
	45		15		35	21	25		22	23	38
	50		10		30	21	30		17	23	43
	55		5		25	21	35		11	23	49
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres.	3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
18 0	65	19	24	41	56	59	33	01	38	32	51	28
5		13	24	47		51	33	09		24	51	36
10		6	24	54		43	33	17		16	51	44
15		0	25	00		36	33	24		8	51	52
20	64	53	25	07		28	33	32		0	52	0
25		47	25	13		20	33	40	37	51	52	9
30		41	25	19		13	33	47		43	52	17
35		34	25	26		5	33	55		35	52	25
40		28	25	32	55	57	34	03		27	52	33
45		21	25	39		50	34	10		19	52	41
50		15	25	45		42	34	18		12	52	48
55		9	25	51		34	34	26		4	52	56
19 0		2	25	58		27	34	33	36	56	53	4
5	63	56	26	04		19	34	41		48	53	12
10		49	26	11		12	34	48		40	53	20
15		43	26	17		4	34	56		33	53	27
20		37	26	23	54	57	35	03		25	53	35
25		30	26	30		49	35	11		17	53	43
30		24	26	36		42	35	18		10	53	50
35		18	26	42		34	35	26		2	53	58
40		11	26	49		27	35	33	35	55	54	5
45		5	26	55		19	35	41		47	54	13
50	62	58	27	02		12	35	48		40	54	20
55		52	27	08		4	35	56		32	54	28
20 0		46	27	14	53	57	36	03		25	54	35
5		39	27	20		49	36	11		18	54	42
10		33	27	27		42	36	18		10	54	50
15		27	27	33		35	36	25		3	54	57
20		21	27	39		27	36	33	34	56	55	4
25		14	27	46		20	36	40		49	55	11
30		8	27	52		13	36	47		42	55	18
35		2	27	58		5	36	55		34	55	26
40	61	55	28	05	52	58	36	02		27	55	33
45		49	28	11		51	36	09		20	55	40
50		43	28	17		44	36	16		13	55	47
55		36	28	23		36	36	24		6	55	[illegible]

Azimuths 45 d.0'. 60 d.0' 75

Houres		12.		1.	11.	Compl.		2.	10.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
21	0	69	0	68	20	21	40	66	6	23	54
	5	68	55		14	21	46		0	24	00
	10		50		9	21	51	65	55	24	05
	15		45		4	21	56		49	24	11
	20		40	67	59	22	01		44	24	16
	25		35		54	22	06		38	24	22
	30		30		49	22	11		33	24	27
	35		25		44	22	16		27	24	33
	40		20		38	22	22		21	24	39
	45		15		33	22	27		16	24	44
	50		10		28	22	32		10	24	50
	55		5		23	22	37		5	24	55
22	0		0		18	22	42	64	59	25	01
	5	67	55		13	22	47		54	25	06
	10		50		8	22	52		48	25	12
	15		45		3	22	57		43	25	17
	20		40	66	58	23	02		37	25	23
	25		35		52	23	08		32	25	28
	30		30		47	23	13		26	25	34
	35		25		42	23	18		21	25	39
	40		20		37	23	23		15	25	45
	45		15		32	23	28		10	25	50
	50		10		27	23	33		4	25	56
	55		5		22	23	38	63	59	26	01
23	0		0		17	23	43		53	26	07
	5	66	55		11	23	49		48	26	12
	10		50		6	23	54		42	26	18
	15		45		1	23	59		37	26	23
	20		40	65	56	24	04		31	26	29
	25		35		51	24	09		26	26	34
	30		30		46	24	14		20	26	40
	35		25		41	24	19		15	26	44
	40		20		36	24	24		9	26	51
	45		15		31	24	29		4	26	56
	50		10		25	24	35	62	58	27	02
	55		5		20	24	40		52	27	7
Azimuths				15 d. 0'.				30 d. 0'.			

Houres		3. 9.		*Compl.*		4. 8.		*Compl.*		5. 7.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
21	0	61	30	28	30	52	29	37	31	33	59	56	1
	5		24	28	36		22	37	38		52	56	8
	10		18	28	42		15	37	45		46	56	14
	15		11	28	49		8	37	52		39	56	21
	20		5	28	55		0	38	0		32	56	28
	25	60	59	29	01	51	53	38	07		25	56	35
	30		53	29	07		46	38	14		18	56	42
	35		46	29	14		39	38	21		12	56	48
	40		40	29	20		32	38	28		5	56	55
	45		34	29	26		25	38	35	32	58	57	2
	50		28	29	32		18	38	42		52	57	8
	55		22	29	38		11	38	49		45	57	15
22	0		15	29	45		4	38	56		39	57	21
	5		9	29	51	50	57	39	03		32	57	28
	10		3	29	57		50	39	10		26	57	34
	15	59	57	30	03		43	39	18		19	57	41
	20		51	30	09		36	39	24		13	57	47
	25		44	30	16		29	39	31		6	57	54
	30		38	30	22		22	39	38		0	58	0
	35		32	30	26		15	39	45	31	54	58	6
	40		26	30	34		8	39	52		47	58	13
	45		29	30	40		1	39	59		41	58	19
	50		14	30	46	49	54	40	06		35	58	25
	55		8	30	52		47	40	13		29	58	31
23	0		1	30	59		40	40	20		22	58	38
	5	58	55	31	05		33	40	27		16	58	44
	10		49	31	11		26	40	34		10	58	50
	15		43	31	17		20	40	40		4	58	56
	20		37	31	23		13	40	47	30	58	59	2
	25		31	31	29		6	40	54		52	59	8
	30		25	31	35	48	59	41	01		46	59	14
	35		19	31	41		53	41	07		40	59	20
	40		12	31	47		45	41	14		34	59	26
	45		6	31	54		39	41	21		28	59	32
	50		0	32	00		32	41	28		22	59	38
	55	57	54	32	6		26	41	34		16	59	44
Azimuths 45 *d.* 0'.						60 *d.* 0'.				75 *d.* 0'.			

Heures		12.		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
24	0	66	0	65	15	24	45	62	48	27	12
	5	65	55		10	24	50		42	27	18
	10		50		5	24	55		37	27	23
	15		45		0	25	00		31	27	29
	20		40	64	55	25	05		26	27	34
	25		35		50	25	10		20	27	40
	30		30		44	25	16		15	27	45
	35		25		39	25	21		9	27	51
	40		20		34	25	26		4	27	56
	45		15		29	25	31	61	58	28	02
	50		10		24	25	36		53	28	07
	55		5		19	25	41		47	28	13
25	0		0		14	25	46		42	28	18
	5	66	55		9	25	51		34	28	26
	10		50		4	25	56		31	28	29
	15		45	63	58	26	01		26	28	34
	20		40		53	26	07		20	28	40
	25		35		48	26	12		15	28	45
	30		30		43	26	17		9	28	51
	35		25		38	26	22		4	28	56
	40		20		33	26	27	60	57	29	03
	45		15		28	26	32		52	29	08
	50		10		23	26	37		47	29	13
	55		5		18	26	42		42	29	18
26	0		0		13	26	47		37	29	23
	5	67	55		7	26	53		31	29	29
	10		50		2	26	58		26	29	34
	15		45	62	57	27	03		20	29	40
	20		40		52	27	08		15	29	45
	25		35		47	27	13		10	29	50
	30		30		42	27	18		4	29	56
	35		25		37	27	23	59	59	30	01
	40		20		32	37	28		53	30	07
	45		15		27	27	33		48	30	12
	50		10		22	27	38		43	30	17
	55		5		16	27	44		37	30	22
Azimuths		15 d. 0'.						30 d. 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
24	0	57	48	32	12	48	19	41	41	30	10	59	50
	5		42	32	18		12	41	48		4	59	56
	10		36	32	24		6	41	54	29	59	60	01
	15		30	32	30	47	59	42	01		53	60	07
	20		24	32	36		52	42	08		47	60	13
	25		18	32	42		46	42	14		41	60	19
	30		12	32	48		39	42	21		36	60	24
	35		6	32	54		33	42	27		30	60	30
	40		0	33	00		26	42	34		24	60	36
	45	56	54	33	06		19	02	41		19	60	41
	50		48	33	12		13	42	47		13	60	47
	55		42	33	18		6	42	54		7	60	53
25	0		36	33	24		0	43	00		2	60	58
	5		30	33	32	46	53	43	07	28	56	61	04
	10		24	33	36		47	43	13		51	61	09
	15		18	33	42		40	43	20		45	61	15
	20		12	33	48		34	43	26		40	61	20
	25		6	33	54		27	43	33		35	61	25
	30		0	34	00		21	43	39		29	61	31
	35	55	54	34	06		15	43	45		24	61	36
	40		48	34	12		8	43	52		18	61	42
	45		42	34	18		2	43	58		13	61	47
	50		36	4	24	45	55	44	05		8	61	52
	55		30	34	30		49	44	11		2	61	58
26	0		24	34	36		43	44	17	27	57	62	03
	5		18	34	42		36	44	24		52	62	08
	10		12	34	48		30	44	30		47	62	13
	15		6	34	53		24	44	36		41	62	18
	20		0	34	59		17	44	43		36	62	24
	25	54	55	35	05		11	44	49		31	62	29
	30		49	35	11		5	44	55		26	62	34
	35		43	35	17		0	45	00		21	62	39
	40		37	35	23	44	53	45	07		16	62	44
	45		31	35	29		46	45	14		11	62	49
	50		25	35	35		40	45	20		6	62	54
	55		19	35	41		34	45	26		1	62	59
Azimuths						16d.0'.				16d.0'.			

Houres		12		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
27	0	63	0	62	11	27	49	59	32	30	28
	5	62	55		6	27	54		26	30	34
	10		50		1	27	59		21	30	39
	15		45	61	56	28	04		16	30	44
	20		40		51	28	09		10	30	50
	25		35		46	28	14		4	30	55
	30		30		41	28	19	58	59	31	01
	35		25		36	28	24		54	31	06
	40		20		30	28	29		49	31	11
	45		15		25	28	35		43	31	17
	50		10		20	28	40		38	31	22
	55		5		15	28	45		32	31	27
28	0		0		10	28	50		27	31	33
	5	61	55		5	28	55		22	31	38
	10		50		0	29	00		16	31	44
	15		45	60	55	29	05		11	31	49
	20		40		50	29	10		6	31	54
	25		35		45	29	15		0	32	00
	30		30		40	29	20	57	55	32	05
	35		25		34	29	26		50	32	10
	40		20		29	29	31		44	32	16
	45		15		24	29	36		39	32	21
	50		10		19	29	41		33	32	27
	55		5		14	29	46		28	32	32
29	0		0		9	29	51		23	32	37
	5	60	55		4	29	56		17	32	43
	10		50	59	59	30	01		12	22	48
	15		45		54	30	06		7	32	53
	20		40		49	30	11		1	32	59
	25		35		43	30	17	56	56	33	04
	30		30		38	30	22		51	33	09
	35		25		33	30	27		45	33	15
	40		20		28	30	32		40	33	20
	45		15		23	30	37		35	33	25
	50		10		18	30	42		29	33	31
	55		5		13	30	47		24	33	36
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres Latit.		3. 9. G.	M.	Compl. G.	M.	4. 8. G.	M.	Compl. G.	M.	5. 7. G.	M.	Compl. G.	M.
27	0	54	13	35	47	44	28	45	32	26	56	63	04
	5		8	35	52		21	45	39		51	63	09
	10		2	35	58		15	45	45		46	63	14
	15	53	56	36	04		9	45	51		41	63	19
	20		50	36	10		3	45	57		36	63	24
	25		44	36	16	43	57	46	03		31	63	29
	30		38	36	22		51	46	09		26	63	34
	35		33	36	27		45	46	15		21	63	39
	40		27	36	33		39	46	21		16	63	44
	45		21	36	39		33	46	27		12	64	48
	50		15	36	45		26	46	34		7	63	53
	55		9	36	51		20	46	40		2	63	58
28	0		3	36	56		14	46	46	25	57	64	03
	5	52	58	37	02		8	46	52		53	64	07
	10		52	37	08		2	46	58		48	64	12
	15		46	37	14	42	56	47	04		43	64	17
	20		40	37	20		51	47	09		38	64	22
	25		35	37	25		45	47	15		34	64	26
	30		29	37	31		39	47	21		29	64	31
	35		23	37	37		33	47	27		25	64	35
	40		17	37	43		27	47	33		20	64	40
	45		12	37	48		21	47	39		15	64	45
	50		6	37	54		15	47	45		11	64	49
	55		0	38	00		9	47	51		6	64	54
29	0	51	54	38	06		3	47	57		2	64	58
	5		49	38	11	41	57	48	03	24	57	65	03
	10		43	38	17		51	48	09		53	65	07
	15		37	38	23		43	48	17		48	65	12
	20		31	38	28		40	48	20		44	65	16
	25		26	38	34		34	48	26		39	65	21
	30		20	38	40		28	48	32		35	65	25
	35		14	38	46		22	48	38		31	65	29
	40		9	38	51		17	48	43		26	65	34
	45		3	38	57		11	48	49		22	65	38
	50	50	57	39	03		5	48	55		17	65	43
	55		52	39	08	40	59	49	0		13	65	47
Azimuths						16*d*.0'.				16*d*. 0'.			

Heures		12		1. 11.		Compl.		2. 10		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
30	0	60	0	59	8	30	52	56	19	33	41
	5	59	55		3	30	57		13	33	47
	10		50	58	58	31	02		8	33	52
	15		45		53	31	07		3	33	57
	20		40		48	31	12	55	57	34	03
	25		35		43	31	17		52	34	08
	30		30		37	31	23		47	34	13
	35		25		32	31	28		41	34	19
	40		20		27	31	33		36	34	24
	45		15		22	31	38		31	34	29
	50		10		17	31	43		25	34	35
	55		5		12	31	48		20	34	40
31	0		0		7	31	53		15	34	45
	5	58	55		2	31	58		9	34	51
	10		50	57	57	32	03		4	34	56
	15		45		52	32	08	54	59	35	01
	20		40		47	32	13		54	35	06
	25		35		42	32	18		48	35	12
	30		30		36	32	23		43	35	17
	35		25		31	32	29		38	35	22
	40		20		26	32	34		32	35	28
	45		15		21	32	39		27	35	33
	50		10		16	32	44		22	35	38
	55		5		11	32	49		17	35	43
32	0		0		6	32	54		11	35	49
	5	57	55		1	32	59		6	35	54
	10		50	56	56	33	04		1	35	59
	15		45		51	33	09	53	55	36	05
	20		40		46	33	14		50	36	10
	25		35		41	33	19		45	36	15
	30		30		36	33	24		40	36	20
	35		25		31	33	29		34	36	26
	40		20		25	33	35		29	36	31
	45		15		20	33	40		24	36	36
	50		10		15	33	45		19	36	41
	55		5		10	33	50		13	36	47
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
30	0	50	46	39	14	40	54	49	06	24	9	65	51
	5		40	39	20		48	49	12		4	65	56
	10		35	39	25		42	49	18		0	65	00
	15		29	39	31		37	49	23	23	56	66	04
	20		23	39	37		31	49	29		52	66	08
	25		18	39	42		25	49	35		47	66	13
	30		12	39	48		20	49	40		43	66	17
	35		7	39	53		14	49	46		39	66	21
	40		1	39	59		8	49	52		35	66	25
	45	49	55	40	05		3	49	57		31	66	29
	50		50	40	10	39	57	50	03		26	66	34
	55		44	40	16		51	50	09		22	66	38
31	0		39	40	21		46	50	14		18	66	42
	5		33	40	27		40	50	20		14	66	46
	10		28	40	32		35	50	25		10	66	50
	15		22	40	38		29	50	31		6	66	54
	20		16	40	44		24	50	36		2	66	58
	25		11	40	49		18	50	42	22	58	67	02
	30		5	40	55		13	50	47		54	67	06
	35		0	41	00		7	50	53		50	67	10
	40	48	54	41	06		2	50	58		46	67	14
	45		49	41	11	38	56	51	04		42	67	18
	50		43	41	17		51	51	09		38	67	22
	55		37	41	22		45	51	15		34	67	26
32	0		32	41	28		40	51	20		30	67	30
	5		26	41	34		34	51	25		26	67	34
	10		21	41	39		29	51	31		22	67	38
	15		15	41	45		24	51	36		18	67	42
	20		10	41	50		18	51	42		14	67	46
	25		4	41	56		13	51	47		10	67	50
	30	47	59	42	01		8	51	52		7	67	53
	35		53	42	07		2	51	58		3	67	57
	40		48	42	12	37	57	52	03	21	59	68	01
	45		43	42	17		5	52	08		55	68	05
	50		37	42	23		46	52	14		51	68	09
	55		32	42	28		41	52	19		48	68	12
Azimuths			45 d. 0'.				60 d. 0'.				75 d. 0'.		

Houres		12		1.	11.	Compl.		2.	10.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
33	0	57	0	56	5	33	55	53	8	36	52
	5	56	55		0	34	00		3	36	57
	10		50	55	55	34	05	52	58	37	02
	15		45		50	34	10		52	37	08
	20		40		45	34	15		47	37	13
	25		35		40	34	20		42	37	18
	30		30		35	34	25		37	37	23
	35		25		30	34	30		31	37	29
	40		20		25	34	35		26	37	34
	45		15		20	34	40		21	37	39
	50		10		15	34	45		16	37	44
	55		5		9	34	51		10	37	50
34	0		0		4	34	56		5	37	55
	5	55	55	54	59	35	01		0	38	00
	10		50		54	35	06	51	54	38	05
	15		45		49	35	11		50	38	10
	20		40		44	35	16		44	38	16
	25		35		39	35	21		39	38	21
	30		30		34	35	26		34	38	26
	35		25		29	35	31		29	38	31
	40		20		24	35	36		23	38	37
	45		15		19	35	41		18	38	42
	50		10		14	35	46		13	38	47
	55		5		9	35	51		8	38	52
35	0		0		4	35	56		3	38	57
	5	54	55	53	59	36	01	50	57	39	03
	10		50		54	36	06		52	39	08
	15		45		49	36	11		47	39	13
	20		40		43	36	17		42	39	18
	25		35		38	36	22		37	39	23
	30		30		33	36	27		31	39	29
	35		25		28	36	32		26	39	34
	40		20		23	36	37		21	39	39
	45		15		18	36	42		16	39	44
	50		10		13	36	47		11	39	49
	55		5		8	36	42		5	39	55
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Latit.		Houres 3. 9. G.	M.	Compl. G.	M.	4. 8. G.	M.	Compl. G.	M.	5. 7. G.	M.	Compl. G.	M.
33	0	47	26	42	34	37	35	52	25	21	44	68	16
	5		21	42	39		30	52	30		40	68	20
	10		15	42	45		25	52	35		36	68	24
	15		10	42	50		20	52	40		33	68	27
	20		4	42	56		15	52	45		29	68	31
	25	46	59	43	01		9	52	51		25	68	35
	30		54	43	06		4	52	56		21	68	39
	35		48	43	12	36	59	53	01		18	68	42
	40		43	43	17		54	53	06		14	68	46
	45		37	43	23		48	53	12		10	68	50
	50		32	43	28		43	53	17		7	68	53
	55		26	43	34		38	53	22		3	68	57
32	0		21	43	39		33	53	27	20	0	69	00
	5		16	43	44		28	53	32		56	69	04
	10		10	43	50		23	53	37		52	69	08
	15		5	43	55		17	53	42		49	69	11
	20		0	44	00		12	53	48		45	69	15
	25	45	54	44	06		7	53	53		42	69	18
	30		49	44	11		2	53	58		38	69	22
	35		44	44	16	35	57	54	03		35	69	25
	40		38	44	22		52	54	08		31	69	29
	45		33	44	27		47	54	13		28	69	32
	50		28	44	32		42	54	18		25	69	36
	55		22	44	38		37	54	23		21	69	39
31	0		17	44	43		32	54	28		17	69	43
	5		12	44	48		27	54	33		14	69	46
	10		6	44	54		22	54	38		10	69	50
	15		1	44	59		17	54	43		7	69	53
	20	44	56	45	04		12	54	48		3	69	57
	25		50	45	10		7	54	53		0	70	00
	30		45	45	15		2	54	58		57	70	03
	35		40	45	20	34	57	55	03		53	70	07
	40		34	45	26		52	55	08		50	70	10
	45		29	45	31		47	55	13		46	70	14
	50		24	45	36		42	55	18		43	70	17
	55		19	45	41		37	55	23		40	70	20
Azimuths		45. d.60'.				60 d. 0'.				75 d. 0'.			

Houres		12		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
36	0	54	0	53	3	36	57	50	0	39	59
	5		55	52	58	37	3	49	55	40	5
	10	53	50		53	37	7		50	40	10
	15		45		48	37	12		45	40	15
	20		40		43	37	17		40	40	20
	25		35		38	37	22		34	40	25
	30		30		33	37	27		29	40	31
	35		25		28	37	32		24	40	36
	40		20		23	37	37		19	40	41
	45		15		18	37	42		14	40	46
	50		10		13	37	47		9	40	51
	55		5		8	37	52		4	40	56
37	0		0		2	37	58	48	58	41	2
	5		55	51	57	38	3		53	41	7
	10	52	50		52	38	8		48	41	12
	15		45		47	38	13		43	41	17
	20		40		42	38	18		38	41	23
	25		35		37	38	23		33	41	27
	30		30		32	38	28		27	41	33
	35		25		27	38	33		22	41	38
	40		20		22	38	38		17	41	43
	45		15		17	38	43		12	41	48
	50		10		12	38	48		7	41	53
	55		5		7	38	53		2	41	58
38	0		0		2	38	58	47	57	42	3
	5	51	55	50	57	39	3		52	44	8
	10		50		52	39	8		46	42	13
	15		45		47	39	13		41	42	19
	20		40		42	39	18		36	42	24
	25		35		37	39	23		31	42	29
	30		30		32	39	28		26	42	34
	35		25		27	39	33		21	42	39
	40		20		22	39	38		16	42	44
	45		15		17	39	43		11	42	49
	50		10		12	39	48		6	42	54
	55		5		7	39	53		0	43	0
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		2. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
36	0	44	13	45	47	34	32	55	28	19	36	70	24
	5		8	45	52		27	55	33		33	70	27
	10		3	45	57		22	55	38		30	70	30
	15	43	58	46	2		17	55	43		27	70	33
	20		52	46	8		13	55	47		23	70	37
	25		47	46	13		8	55	52		20	70	40
	30		42	46	18		3	55	57		17	70	43
	35		37	46	23	33	58	56	2		13	70	47
	40		32	46	28		53	56	7		10	70	50
	45		26	46	34		48	56	12		7	70	53
	50		21	46	39		44	56	16		4	70	56
	55		16	46	44		39	56	21		1	70	59
37	0		11	46	49		34	56	26	18	57	71	3
	5		6	46	54		29	56	31		54	71	6
	10		0	47	0		24	56	36		51	71	9
	15	42	55	47	5		20	56	40		48	71	12
	20		50	47	10		15	56	45		45	71	15
	25		45	47	15		10	56	50		41	71	19
	30		40	47	20		5	56	55		38	71	22
	35		35	47	25		1	56	59		35	71	25
	40		29	47	31	32	56	57	4		32	71	28
	45		24	47	36		51	57	9		29	71	31
	50		19	47	41		46	57	14		26	71	34
	55		14	47	46		42	57	18		23	71	38
38	0		9	47	51		37	57	23		20	71	40
	5		4	47	56		32	57	28		17	71	43
	10	41	59	48	1		28	57	32		14	71	46
	15		53	48	7		23	57	37		11	71	49
	20		48	48	12		18	57	42		7	71	53
	25		43	48	17		14	57	46		4	71	56
	30		38	48	22		9	57	51		1	71	59
	35		33	48	27		5	57	55	17	58	72	2
	40		28	48	32		0	58	0		55	72	5
	45		23	48	37	31	55	58	5		52	72	8
	50		18	48	42		51	58	9		49	72	11
	55		13	48	47		46	58	14		46	72	14
Azimuths.		45 d. 0'.				60 d. 0'.				75 d. 0'.			

Houres Latit.		12.		I. II.		*Compl.*		2. 10.		*Compl.*	
		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
39	0	51	0	50.	01	39	58	46	55	43	5
	5	50	55	49	56	40	4		50	43	10
	10		50		51	40	8		45	43	15
	15		45		46	40	14		40	43	20
	20		40		41	40	19		35	43	25
	25		35		36	40	24		30	43	30
	30		30		31	40	28		25	43	35
	35		25		26	40	34		20	43	40
	40		20		21	40	39		15	43	45
	45		15		16	40	44		10	43	50
	50		10		11	40	49		4	43	56
	55		5		6	40	53	45	59	44	1
40	0		0		1	40	59		54	44	6
	5	49	55	48	56	41	4		49	44	11
	10		50		51	41	9		44	44	16
	15		45		46	41	14		39	44	31
	20		40		41	41	19		34	44	36
	25		35		36	41	24		29	44	31
	30		30		31	41	29		24	44	36
	35		25		26	41	34		19	44	41
	40		20		21	41	39		14	44	46
	45		15		16	41	44		9	44	51
	50		10		11	41	49		4	44	56
	55		5		6	41	54	44	59	45	1
41	0		0		1	41	59		54	45	6
	5	48	55	47	56	42	4		48	45	11
	10		50		51	42	9		43	45	17
	15		45		46	42	14		38	45	22
	20		40		41	42	19		33	45	27
	25		35		36	42	24		28	45	32
	30		30		31	42	29		23	45	37
	35		25		26	42	34		18	45	42
	40		20		21	42	39		13	45	47
	45		15		16	42	44		8	45	52
	50		10		11	42	49		3	45	57
	55		5		5	42	55	43	58	46	2
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3.	9.	Compl.		4.	6.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
39	0	41	8	48	52	31	42	58	18	17	43	72	17
	5		3	48	57		37	58	23		40	72	20
	10	40	57	49	3		32	58	28		38	72	22
	15		52	49	8		28	58	32		35	72	25
	20		47	49	13		23	58	37		32	72	28
	25		42	49	18		19	58	41		29	72	31
	30		37	49	23		14	58	46		26	72	34
	35		32	49	28		10	58	50		23	72	37
	40		27	49	33		5	58	55		20	72	40
	45		22	49	38		1	58	59		17	72	43
	50		17	49	43	30	56	59	4		14	72	46
	55		12	49	48		52	59	8		11	72	49
40	0		7	49	53		47	59	13		9	72	51
	5		2	49	58		43	59	17		6	72	54
	10	39	57	50	3		38	59	22		3	72	57
	15		52	50	8		34	59	26		0	73	0
	20		47	50	13		30	59	30	16	57	73	3
	25		42	50	18		25	59	35		54	73	6
	30		37	50	23		21	59	40		51	73	8
	35		32	50	28		16	59	44		49	73	11
	40		27	50	33		12	59	48		46	73	14
	45		2	50	38		8	59	52		43	73	17
	50		17	50	43		3	59	57		40	73	20
	55		12	50	48	29	59	60	1		38	73	22
41	0		8	50	52		54	60	6		35	73	25
	5		3	50	57		50	60	10		32	73	28
	10	38	58	51	2		46	60	14		29	73	31
	15		53	51	7		41	60	19		27	73	33
	20		48	51	12		37	60	23		24	73	36
	25		4	51	17		33	60	27		21	73	39
	30		38	51	22		28	60	32		18	73	42
	35		33	51	27		24	60	36		16	73	44
	40		28	51	32		20	60	40		13	73	47
	45		23	51	37		15	60	45		10	73	50
	50		18	51	42		11	60	49		8	73	52
	55		13	51	47		7	60	53		5	73	55
Azimuths. 45 *d.* 0'.								60 *d.* 0'.				75 *d.* 0'.	

Houres		12.		I. II.		*Compl.*		I. II.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
42	0	47	0	47	1	42	59	43	53	46	7
	5	46	55	46	56	43	4		48	46	12
	10		50		51	43	9		43	46	17
	15		45		46	43	14		38	46	22
	20		40		41	43	19		33	36	27
	25		35		36	43	24		28	46	32
	30		30		31	43	29		23	46	37
	35		25		26	43	34		18	46	42
	40		20		21	43	39		13	46	47
	45		15		15	43	45		8	46	52
	50		10		10	43	50		3	46	57
	55		5		5	43	55	42	58	47	2
43	0		0		0	44	0		53	47	7
	5	45	55	45	55	44	5		48	47	12
	10		50		50	44	10		43	47	17
	15		45		55	44	15		38	47	22
	20		40		40	44	20		33	47	27
	25		35		35	44	25		28	47	32
	30		30		30	44	30		23	47	37
	35		25		25	44	35		18	47	42
	40		20		20	44	40		13	47	47
	45		15		15	44	45		8	47	52
	50		10		10	44	50		3	47	57
	55		5		5	44	55	41	58	48	2
44	0		0		0	45	0		53	48	7
	5	44	55	44	55	45	5		48	48	12
	10		50		50	45	10		43	48	17
	15		45		45	45	15		38	48	22
	20		40		40	45	20		33	48	27
	25		35		35	45	25		28	48	32
	30		30		30	45	30		23	48	37
	35		25		25	45	35		18	48	42
	40		20		20	45	40		13	48	47
	45		15		15	45	45		8	48	52
	50		10		10	45	50		3	48	57
	55		5		5	45	55	40	59	49	1

Azimuths 15 *d.* 0′. 30 *d.* 0′.

Houres		3.	9.	*Compl.*		4.	8.	*Compl.*		5.	7.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
42	0	38	9	51	51	29	2	57	57	16	2	73	58
	5		4	51	56	28	58	61	2		0	74	0
	10	37	59	52	1		54	61	6		57	74	3
	15		54	52	6		50	61	10		54	74	6
	20		49	52	11		46	61	14		52	74	8
	25		44	52	16		41	61	19		49	74	11
	30		39	52	21		37	61	23		46	74	14
	35		35	52	25		33	61	27		44	74	16
	40		30	52	30		29	61	31		41	74	19
	45		25	52	35		25	61	35		38	74	22
	50		20	52	40		20	61	40		36	74	24
	55		15	52	45		16	61	44		33	74	27
43	0		10	52	50		12	61	48		31	74	29
	5		5	52	55		8	61	52		28	74	32
	10		1	52	59		4	61	56		26	74	34
	15	36	56	53	4	27	59	62	1		23	74	37
	20		51	53	9		55	62	5		20	74	40
	25		46	53	14		51	62	9		18	74	42
	30		41	53	19		47	62	13		15	74	45
	35		37	53	23		43	62	17		13	74	47
	40		32	53	28		39	62	21		10	74	50
	45		27	53	33		35	62	25		8	74	52
	50		22	53	38		31	62	29		5	74	55
	55		18	53	42		27	62	33		3	74	57
47	0		13	53	47		22	62	38		0	75	0
	5		8	53	52		18	62	42	14	58	75	2
	10		3	53	57		14	62	46		55	75	5
	15	35	58	54	2		10	62	50		53	75	7
	20		54	54	6		6	62	54		50	75	10
	25		49	54	11		2	62	58		48	75	12
	30		44	54	16	26	58	63	2		45	75	15
	35		39	54	21		54	63	6		43	75	17
	40		35	54	25		50	63	10		40	75	20
	45		30	54	30		45	63	14		38	75	22
	50		25	54	35		42	63	18		36	75	24
	55		21	54	39		38	63	22		33	75	27
Azimuths		45 *d.* 0'.				60 *d.* 0'.				75 *d.* 0'.			

Houres / Latit.		12. G.	12. M.	1. 11. G.	1. 11. M.	Compl. G.	Compl. M.	2. 10. G.	2. 10. M.	Compl. G.	Compl. M.
45	0	45	0	44	0	46	0	40	54	49	6
	5	44	55	43	55	46	5		49	49	11
	10		50		50	46	10		44	49	16
	15		45		45	46	15		39	49	21
	20		40		40	46	20		34	49	26
	25		35		35	46	25		29	49	31
	30		30		30	46	30		24	49	36
	35		25		25	46	35		19	49	41
	40		20		20	46	40		14	49	46
	45		15		15	46	45		9	49	51
	50		10		10	46	50		4	49	56
	55		5		5	46	55	39	59	50	1
46	0		0		0	47	0		54	50	6
	5	43	55	42	56	47	4		49	50	11
	10		50		51	47	9		45	50	16
	15		45		46	47	14		40	50	20
	20		40		41	47	19		35	50	25
	25		35		36	47	24		30	50	30
	30		30		31	47	29		25	50	35
	35		25		26	47	34		20	50	40
	40		20		21	47	39		15	50	45
	45		15		16	47	44		10	50	50
	50		10		11	47	49		5	50	55
	55		5		6	47	54		0	51	0
47	0		0		1	47	59	38	55	51	5
	5	42	55	41	56	48	4		50	51	10
	10		50		51	48	9		46	51	14
	15		45		46	48	14		41	51	19
	20		40		41	48	19		36	51	24
	25		35		36	48	24		31	51	29
	30		30		31	48	29		26	51	34
	35		25		26	48	34		21	51	39
	40		20		21	48	39		16	51	44
	45		15		16	48	44		11	51	49
	50		10		11	48	49		7	51	53
	55		5		6	48	54		2	51	58

Azimuths 15 *d.* 0'. 30 *d.* 0'.

Houres.		3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G,	M.	G.	M.
45	0	35	16	54	44	26	34	63	26	14	31	75	29
	5		11	54	49		30	63	30		28	75	32
	10		6	54	54		26	63	34		26	75	34
	15		2	54	58		22	63	38		23	75	37
	20	34	57	55	3		18	63	42		21	75	39
	25		52	55	8		14	63	46		19	75	41
	30		48	55	12		10	63	50		16	75	44
	35		43	55	17		6	63	54		14	75	46
	40		38	55	22		2	63	58		11	75	49
	45		34	55	26	25	58	64	2		9	75	51
	50		29	55	31		54	64	6		7	75	53
	55		24	55	36		50	64	10		4	75	56
46	0		20	55	40		46	64	14		2	75	58
	5		15	55	45		42	64	18		0	76	0
	10		10	55	50		39	64	21	13	57	76	3
	15		6	55	54		35	64	25		55	76	5
	20		1	55	59		31	64	29		53	76	7
	25	33	56	56	4		27	64	33		50	76	10
	30		52	56	8		23	64	37		48	76	12
	35		47	56	13		19	64	41		46	76	14
	40		42	56	18		15	64	45		43	76	17
	45		38	56	22		11	64	49		41	76	19
	50		33	56	27		8	64	52		39	76	21
	55		29	56	31		4	64	56		36	76	24
47	0		24	56	36		0	65	0		34	76	26
	5		19	56	41	24	56	65	4		32	76	28
	10		15	56	45		52	65	8		30	76	30
	15		10	56	50		48	65	12		27	76	33
	20		6	56	54		45	65	15		25	76	35
	25		1	56	59		41	65	19		23	76	37
	30	32	56	57	4		37	65	23		20	76	40
	35		52	57	8		33	65	27		18	76	42
	40		47	57	13		29	65	31		16	76	44
	45		43	57	17		25	65	34		14	76	46
	50		38	57	22		22	65	38		12	76	48
	55		34	57	26		18	65	42		9	76	51

Azimuths 45 d. 0'. 60 d. 0'. 75 d. 0'.

Houres		12		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
48	0	42	0	41	1	48	59	37	57	52	03
	5	31	55	40	56	49	04		52	52	08
	10		50		51	49	09		47	52	13
	15		45		46	49	14		42	52	18
	20		40		41	49	19		37	52	23
	25		35		36	49	24		32	52	28
	30		30		31	49	29		28	52	32
	35		25		26	49	34		23	52	37
	40		20		21	49	39		18	52	42
	45		15		16	49	44		13	52	47
	50		10		11	49	49		8	52	52
	55		5		6	49	54		3	52	57
49	0		0		1	49	59	36	58	53	02
	5	40	55	39	56	50	04		54	53	06
	10		50		51	50	09		49	53	11
	15		45		46	50	14		44	53	16
	20		40		41	50	19		39	53	21
	25		35		36	50	24		34	53	26
	30		30		31	50	29		29	53	31
	35		25		26	50	34		24	53	35
	40		20		21	50	39		20	53	40
	45		15		16	50	44		15	53	45
	50		10		11	50	49		10	53	50
	55		5		6	50	54		5	53	55
50	0		0		1	50	58		0	54	00
	5	41	55	38	57	51	03	35	55	54	05
	10		50		52	51	08		51	54	09
	15		45		47	51	13		46	54	14
	20		40		42	51	18		41	54	19
	25		35		37	51	23		36	54	24
	30		30		32	51	28		31	54	29
	35		25		27	51	33		27	54	33
	40		20		22	51	38		22	54	38
	45		15		17	51	43		17	54	43
	50		10		12	51	48		12	54	48
	55		5		7	51	53		7	54	53
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres	Latit.	3. 9. G.	M.	Compl. G.	M.	4. 8. G.	M.	Compl. G.	M.	5. 7. G.	M.	Compl. G.	M.
48	0	32	29	57	31	24	14	65	46	13	7	76	53
	5		24	57	35		10	65	49		5	76	55
	10		20	57	40		7	65	53		3	76	57
	15		15	57	45		3	65	57		0	77	00
	20		11	57	49	23	59	66	01	12	58	77	02
	25		6	57	54		56	66	04		56	77	04
	30		2	57	58		52	66	08		54	77	06
	35	31	57	58	03		48	66	12		52	77	08
	40		53	58	07		44	66	16		49	77	11
	45		48	58	12		41	66	19		47	77	13
	50		44	58	16		37	66	23		45	77	15
	55		39	58	21		33	66	27		43	77	17
49	0		35	58	25		29	66	30		41	77	19
	5		30	58	30		26	66	34		39	77	21
	10		16	58	34		22	66	38		36	77	24
	15		21	58	39		19	66	41		34	77	26
	20		17	58	43		15	66	45		32	77	28
	25		12	58	48		11	66	49		30	77	30
	30		8	58	52		7	66	53		28	77	32
	35		3	58	57		4	66	56		26	77	34
	40	30	59	59	01		0	67	00		24	77	36
	45		54	59	06	22	57	67	03		21	77	39
	50		50	59	10		53	67	07		19	77	41
	55		45	59	15		49	67	11		17	77	43
50	0		41	59	19		46	67	14		15	77	45
	5		36	59	24		42	67	18		13	77	47
	10		32	59	28		38	67	22		11	77	49
	15		28	59	32		35	67	25		9	77	51
	20		23	59	37		31	67	29		7	77	53
	25		19	59	41		28	67	32		4	77	56
	30		14	59	46		24	67	36		3	77	57
	35		10	59	50		20	67	40		1	77	59
	40		5	59	55		17	67	43	11	58	78	02
	45		1	59	59		13	67	47		56	78	04
	50	29	57	60	03		10	67	50		54	78	06
	55		52	60	08		6	67	54		52	78	08
Azimuths		45 d. 0'.				60 d. 0'.				75 d. 0'.			

Houres		12		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
51	0	39	0	38	2	51	58	35	2	54	57
	5	38	55	37	57	52	03	34	58	55	02
	10		50		52	52	08		53	55	07
	15		45		47	52	13		48	55	12
	20		40		42	52	18		43	55	17
	25		35		37	52	23		38	55	21
	30		30		32	52	28		34	55	26
	35		25		27	52	33		29	55	31
	40		20		22	52	38		24	55	36
	45		15		17	52	43		19	55	41
	50		10		12	52	48		15	55	45
	55		5		7	52	53		10	55	50
52	0		0		2	52	58		5	55	55
	5	37	55	36	57	53	03		0	56	00
	10		50		53	53	07	33	55	56	05
	15		45		48	53	12		51	56	09
	20		40		43	53	17		46	56	14
	25		35		38	53	22		41	56	19
	30		30		33	53	27		36	56	24
	35		25		28	53	32		32	56	28
	40		20		23	53	37		27	56	33
	45		15		18	53	42		22	56	38
	50		10		13	53	47		17	56	43
	55		5		8	53	52		12	56	48
53	0		0		3	53	57		8	56	52
	5	36	55	35	58	54	02		3	56	57
	10		50		53	54	07	32	58	57	02
	15		45		48	54	12		53	57	07
	20		40		43	54	17		49	57	11
	25		35		38	54	22		44	57	16
	30		30		33	54	27		39	57	21
	35		25		28	54	32		34	57	26
	40		20		23	54	37		30	5	30
	45		15		18	54	42		25	5	35
	50		10		14	54	46		20	57	40
	55		5		9	54	51		15	57	45
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houses		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
51	0	29	48	60	12	22	3	67	57	11	50	78	10
	5		43	60	17	21	59	68	01		48	78	12
	10		39	60	21		55	68	05		46	78	14
	15		35	60	25		52	68	08		44	78	16
	20		30	60	30		48	68	12		42	78	18
	25		26	60	34		45	68	15		40	78	20
	30		21	60	39		41	68	19		38	78	22
	35		17	60	43		38	68	22		36	78	24
	40		13	60	47		34	68	26		34	78	26
	45		8	60	52		31	68	29		32	78	28
	50		4	60	56		27	68	33		30	78	30
	55	28	59	61	01		24	68	36		28	78	32
52	0		55	61	05		20	68	40		26	78	34
	5		51	61	09		17	68	43		24	78	36
	10		46	61	14		13	68	47		22	78	38
	15		42	61	18		10	68	50		20	78	40
	20		38	61	22		6	68	54		18	78	42
	25		33	61	27		3	68	57		16	78	44
	30		29	61	31	20	59	69	01		14	78	46
	35		25	61	35		56	69	04		12	78	48
	40		20	61	40		52	69	07		10	78	50
	45		16	61	44		49	69	11		8	78	52
	50		12	61	48		46	69	14		6	78	54
	55		7	61	53		42	69	18		4	78	56
53	0		3	61	57		39	69	21		2	78	58
	5	27	59	62	01		35	69	25		0	79	00
	10		55	62	05		32	69	28	10	58	79	02
	15		50	62	10		28	69	32		56	79	04
	20		46	62	14		25	69	35		54	79	06
	25		41	62	18		22	69	38		52	79	08
	30		37	62	23		18	69	42		50	79	09
	35		33	62	27		15	69	45		49	79	11
	40		29	62	31		11	69	49		47	79	13
	45		24	62	36		8	69	52		45	79	15
	50		20	62	40		5	69	55		43	79	17
	55		16	62	44		1	69	59		41	79	19
Azimuths						16d.0'.				16d.0'.			

Houres Latit.		12		1. 11.		Compl.		2. 10.		Compl.	
		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
54	0	36	0	35	4	54	56	32	11	57	49
	5	35	55	34	59	55	01		6	57	54
	10		50		54	55	06		1	57	59
	15		45		49	55	11	31	57	58	3
	20		40		44	55	16		52	58	8
	25		35		39	55	21		47	58	13
	30		30		34	55	26		42	58	18
	35		25		29	55	31		38	58	22
	40		20		24	55	36		33	58	27
	45		15		19	55	41		28	58	32
	50		10		14	55	46		23	58	37
	55		5		9	55	51		19	58	41
55	0		0		4	55	56		14	58	46
	5	34	55	33	59	56	1		9	58	51
	10		50		54	56	6		5	58	55
	15		45		50	56	10		0	59	0
	20		40		45	56	15	30	55	59	5
	25		35		40	56	20		50	59	10
	30		30		35	56	25		46	59	14
	35		25		30	56	30		41	59	19
	40		20		25	56	35		36	59	24
	45		15		20	56	40		32	59	28
	50		10		15	56	45		27	59	33
	55		5		10	56	50		22	59	38
56	0		0		5	56	55		17	59	43
	5	33	55		0	57	0		13	59	44
	10		50	32	55	57	5		8	59	52
	15		45		50	57	10		3	59	57
	20		40		45	57	15	29	59	60	1
	25		35		40	57	20		54	60	6
	30		30		36	57	24		49	60	11
	35		25		31	57	29		45	60	15
	40		20		26	57	34		40	60	20
	45		15		21	57	39		35	60	25
	50		10		16	57	44		31	60	29
	55		5		11	57	49		26	60	34
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
54	0	27	12	62	48	19	58	70	2	10	39	79	21
	5		7	62	53		54	70	6		37	79	13
	10		3	62	57		51	70	9		35	79	25
	15	26	59	63	1		48	70	12		33	79	27
	20		54	63	6		44	70	16		31	79	29
	25		50	63	10		41	70	19		29	79	31
	30		46	63	14		38	70	22		28	79	32
	35		42	63	18		34	70	26		26	79	34
	40		37	63	23		31	70	29		24	79	36
	45		33	63	27		28	70	32		22	79	38
	50		29	63	31		24	70	36		20	79	40
	55		25	63	35		21	70	39		18	79	42
55	0		20	63	40		18	70	42		16	79	44
	5		16	63	44		14	70	46		14	79	46
	10		12	63	48		11	70	49		13	79	47
	15		8	63	52		8	70	52		11	79	49
	20		4	63	56		4	70	56		9	99	51
	25	25	59	64	1		1	70	59		7	79	53
	30		55	64	5	18	58	71	2		5	79	55
	35		51	64	9		55	71	5		3	79	57
	40		47	64	13		51	71	9		1	79	59
	45		43	64	17		48	71	12		0	79	0
	50		38	64	22		45	71	15	9	58	80	2
	55		34	64	26		41	71	19		56	80	4
56	0		30	64	30		38	71	22		54	80	6
	5		26	64	34		35	71	25		52	80	8
	10		22	64	38		32	71	28		50	80	10
	15		17	64	43		28	71	32		49	80	11
	20		13	64	47		25	71	35		47	80	13
	25		9	64	51		22	71	38		45	80	15
	30		5	64	55		19	71	41		43	80	17
	35		1	64	59		15	71	45		41	80	19
	40	24	57	65	3		12	71	48		40	80	20
	45		52	65	8		9	71	51		38	80	22
	50		48	65	12		6	71	54		36	80	24
	55		44	65	16		3	71	57		34	80	26
Azimuths		45 *d.* 0'.				60 *d.* 0'.				75 *d.* 0'.			

Houres		12		1.	11.	Compl.		2.	10.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
57	0	33	0	32	6	57	54	29	21	60	39
	5	32	55		1	57	59		17	60	43
	10		50	31	56	58	4		12	60	48
	15		45		51	58	9		7	60	53
	20		40		46	58	14		3	60	57
	25		35		46	58	19	28	58	61	2
	30		30		36	58	24		53	61	7
	35		25		31	58	29		49	61	11
	40		20		27	58	33		44	61	16
	45		15		22	58	38		39	61	21
	50		10		17	58	43		35	61	25
	55		5		12	58	48		30	61	30
58	0		0		7	58	53		25	61	35
	5	31	55		2	58	58		21	61	39
	10		50	30	57	59	3		16	61	44
	15		45		52	59	8		11	61	49
	20		40		47	59	13		7	61	53
	25		35		42	59	18		2	61	58
	30		30		37	59	23	27	57	62	3
	35		25		32	59	28		53	62	7
	40		20		27	59	33		48	62	12
	45		15		23	59	37		43	62	17
	50		10		18	59	42		39	62	21
	55		5		13	59	47		34	62	26
59	0		0		8	59	52		29	62	31
	5	30	55		2	59	57		25	62	35
	10		50	29	58	60	2		20	62	40
	15		45		53	60	7		16	62	44
	20		40		48	60	12		11	62	49
	25		35		43	60	17		6	62	54
	30		30		38	60	22		2	62	58
	35		25		33	60	27	26	57	63	3
	40		20		28	60	32		53	63	7
	45		15		24	60	36		48	63	12
	50		10		19	60	41		43	63	17
	55		5		14	60	46		38	63	22
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
57	0	24	40	65	20	17	59	72	1	9	32	80	28
	5		36	65	24		56	72	4		31	80	29
	10		32	65	28		53	72	7		29	80	31
	15		27	65	33		50	72	10		27	80	33
	20		23	65	37		47	72	13		25	80	35
	25		19	65	41		43	72	17		24	80	36
	30		15	65	45		40	72	20		22	80	38
	35		11	65	49		37	72	23		20	80	40
	40		7	65	53		34	72	26		18	80	42
	45		3	65	57		31	72	29		16	80	44
	50	23	59	66	1		27	72	33		15	80	45
	55		54	66	6		24	72	36		13	80	47
58	0		50	66	10		21	72	39		11	80	49
	5		46	66	14		18	72	42		9	80	51
	10		42	66	18		15	72	45		8	80	52
	15		38	66	22		12	72	48		6	80	54
	20		34	66	26		8	72	52		4	80	56
	25		30	66	30		5	72	55		2	80	58
	30		26	66	34		2	72	58		1	80	59
	35		22	66	38		0	73	0	8	59	80	1
	40		17	66	43	16	56	73	4		57	80	3
	45		13	66	47		53	73	7		56	81	4
	50		9	66	51		50	73	10		54	81	6
	55		5	66	55		46	73	14		52	81	8
59	0		1	66	59		43	73	17		50	81	10
	5	22	57	67	3		40	73	20		49	81	11
	10		53	67	7		37	73	23		47	81	13
	15		49	67	11		34	73	26		45	81	15
	20		45	67	15		31	73	29		43	81	17
	25		41	67	19		28	73	32		42	81	18
	30		37	67	23		25	73	35		40	81	20
	35		33	67	27		22	73	38		38	81	22
	40		2	67	31		18	73	42		37	81	23
	45		25	67	35		15	73	45		35	81	25
	50		21	67	39		12	73	48		33	81	27
	55		16	67	44		9	73	51		32	81	28
Azimuths			45. *d.* 0'.				60 *d.* 0'.				75 *d.* 0'.		

Houres Latit.		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
60	0		0	29	9	60	51	26	34	63	26
	5	29	55		4	60	56		29	63	31
	10		50	28	59	61	1		25	63	35
	15		45		54	61	6		20	63	40
	20		40		49	61	11		15	63	45
	25		35		44	61	16		11	63	49
	30		30		39	61	21		6	63	54
	35		25		34	61	26		2	63	58
	40		20		30	61	30	25	57	64	3
	45		15		25	61	35		52	64	8
	50		10		20	61	40		48	64	12
	55		5		15	61	45		43	64	17
61	0		0		10	61	50		39	64	21
	5	28	55		5	61	55		34	64	26
	10		50		0	61	0		29	64	31
	15		45	27	55	62	5		25	64	35
	20		40		50	62	10		20	64	40
	25		35		45	62	15		16	64	44
	30		30		40	62	20		11	64	49
	35		25		36	62	24		6	64	54
	40		20		31	62	29		2	64	58
	45		15		26	62	34	24	57	65	3
	50		10		21	62	39		53	65	7
	55		5		16	62	44		48	65	12
62	0		0		11	62	49		43	65	17
	5	29	55		6	62	54		39	65	21
	10		50		1	62	59		34	65	26
	15		45	26	56	63	4		30	65	30
	20		40		51	63	9		25	65	35
	25		35		47	63	13		21	65	40
	30		30		42	63	18		16	65	44
	35		25		37	63	23		11	65	49
	40		20		32	63	28		7	65	53
	45		15		27	63	33		2	65	58
	50		10		22	63	38	23	58	66	2
	55		5		17	63	43		53	66	7
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
60	0	22	12	67	47	16	6	73	54	8	30	81	30
	5		8	67	52		3	73	57		28	81	32
	10		4	67	56		0	74	0		27	81	33
	15		0	68	0	15	57	74	3		25	81	35
	20	21	56	68	4		54	74	6		23	81	37
	25		52	68	8		51	74	9		21	81	39
	30		48	68	12		48	74	12		20	81	42
	35		44	68	16		45	74	15		18	81	44
	40		40	68	20		42	74	18		16	81	40
	45		36	68	24		39	74	21		15	81	45
	50		32	68	28		36	74	24		13	81	47
	55		28	68	32		32	74	28		12	81	48
61	0		24	68	36		29	74	31		10	81	50
	5		20	68	40		26	74	34		8	81	52
	10		16	68	44		23	74	37		7	81	53
	15		12	68	48		20	74	40		5	81	55
	20		8	68	52		17	74	43		3	81	57
	25		4	68	56		14	74	46		2	81	58
	30		0	69	0		11	74	49		0	82	0
	35	20	56	69	4		8	74	52	7	58	82	2
	40		52	69	8		5	74	55		57	82	3
	45		48	69	12		2	74	58		55	82	5
	50		44	69	16	14	59	75	1		53	82	7
	55		40	69	20		56	75	4		52	82	8
62	0		36	69	24		53	75	7		50	82	10
	5		32	69	28		50	75	10		49	82	11
	10		28	69	32		47	75	13		47	82	13
	15		24	69	36		44	75	16		45	82	15
	20		20	69	40		41	75	19		44	82	16
	25		16	69	44		38	75	22		42	82	18
	30		12	69	48		35	75	25		40	82	20
	35		9	69	51		32	75	28		39	82	21
	40		5	69	55		29	75	31		37	82	23
	45		1	69	59		26	75	34		36	82	24
	50	19	57	70	3		23	75	37		34	82	26
	55		53	70	7		21	75	39		32	82	28

Azimuths. 45 *d.* 0'. 60 *d.* 0'. 75 *d.* 0'.

Houres		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
63	0	27	0	26	12	63	48	23	49	66	11
	5	26	55		7	63	53		44	66	16
	10		50		2	63	58		39	66	21
	15		45	25	58	64	2		35	66	25
	20		40		53	64	7		30	66	30
	25		35		48	64	12		26	66	34
	30		30		43	64	17		21	66	39
	35		25		38	64	22		17	66	43
	40		20		33	64	27		12	66	48
	45		15		28	64	32		8	66	52
	50		10		23	64	37		3	66	57
	55		5		18	64	42	22	58	67	2
64	0		0		14	64	46		54	67	6
	5	25	55		9	64	51		49	67	11
	10		50		4	64	56		45	67	15
	15		45	24	59	65	1		40	67	20
	20		40		54	65	6		36	67	24
	25		35		49	65	11		31	67	29
	30		30		44	65	16		27	67	33
	35		25		39	65	21		22	67	38
	40		20		34	65	26		18	67	42
	45		15		30	65	30		13	67	47
	50		10		25	65	35		9	67	51
	55		5		20	65	40		4	67	56
65	0		0		15	65	45	21	59	68	1
	5	24	55		10	65	50		55	68	5
	10		50		5	65	55		50	68	10
	15		45		0	66	0		46	68	14
	20		40	23	55	66	5		41	68	19
	25		35		50	66	10		37	68	23
	30		30		46	66	14		32	68	28
	35		25		41	66	19		28	68	32
	40		20		36	66	24		23	68	37
	45		15		31	66	29		19	68	41
	50		10		26	66	34		14	68	46
	55		5		21	66	39		10	68	50
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres	3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.	G.	M	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
63 0	19	49	70	11	14	18	75	42	7	31	82	29
5		45	70	15		15	75	45		29	82	31
10		41	70	19		12	75	48		28	82	32
15		37	70	23		9	75	51		26	82	34
20		33	70	27		6	75	54		24	82	36
25		29	70	31		3	75	57		23	82	37
30		25	70	35		0	76	0		21	82	39
35		21	70	39	13	57	76	3		20	82	40
40		17	70	43		54	76	6		18	82	42
45		13	70	47		51	76	9		16	82	44
50		10	70	50		48	76	12		15	82	45
55		6	70	54		45	76	15		13	82	47
64 0		2	70	58		42	76	18		12	82	48
5	18	58	71	2		39	76	21		10	82	50
10		54	71	6		36	76	24		9	82	51
15		50	71	10		34	76	26		7	82	53
20		46	71	14		31	76	29		5	82	55
25		42	71	18		28	76	32		4	82	56
30		38	71	22		25	76	35		2	82	58
35		34	71	26		22	76	38		1	82	59
40		30	71	30		19	76	41	6	59	83	1
45		27	71	33		16	76	44		58	83	2
50		23	71	37		13	76	47		56	83	4
55		19	71	41		10	76	50		54	83	6
65 0		15	71	45		7	76	53		53	83	7
5		11	71	49		5	76	55		51	83	9
10		07	71	53		2	76	58		50	83	10
15		3	71	57	12	59	77	1		48	83	12
20	17	59	72	1		56	77	4		47	83	13
25		56	72	5		53	77	7		45	83	15
30		52	72	8		50	77	10		44	83	16
35		48	72	12		47	77	13		42	83	18
40		44	72	16		44	77	16		41	83	19
45		40	72	20		42	77	18		39	83	21
50		36	72	24		39	77	21		37	83	23
55		32	72	28		37	77	23		36	83	24

Azimuths. 45 *d.*0'. 60 *d.*0'. 75 *d.*0'.

Houres		12		1. 11.		*Compl.*		2. 10.		*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M
66	0	24	0	23	16	65	44	21	5	68	54
	5	23	55		11	66	49		1	68	59
	10		50		6	66	54	20	56	69	4
	15		45		2	66	58		52	69	8
	20		40	22	57	67	3		47	69	13
	25		35		52	67	8		43	69	17
	30		30		47	67	13		38	69	22
	35		25		42	67	18		34	69	26
	40		20		37	67	23		29	69	31
	45		15		32	67	28		25	69	35
	50		10		27	67	33		20	69	40
	55		5		23	67	37		16	69	44
67	0		0		18	67	42		11	69	49
	5	22	55		13	67	47		7	69	53
	10		50		8	67	52		2	69	58
	15		45		3	67	57	19	58	70	2
	20		40	21	58	68	2		53	70	7
	25		35		53	68	7		49	70	11
	30		30		48	68	12		44	70	16
	35		25		43	68	17		40	70	20
	40		20		39	68	21		35	70	25
	45		15		34	68	26		31	70	29
	50		10		29	68	31		26	70	34
	55		5		24	68	36		22	70	38
68	0		0		19	68	41		17	70	43
	5	21	55		14	68	46		13	70	47
	10		50		9	68	51		8	70	52
	15		45		4	68	56		4	70	56
	20		40		0	69	0	18	59	71	1
	25		35	20	55	69	5		55	71	5
	30		30		50	69	10		50	71	10
	35		25		45	69	15		46	71	14
	40		20		40	69	20		41	71	19
	45		15		35	69	25		37	71	23
	50		10		30	69	30		32	71	28
	55		5		25	69	35		28	71	32
Azimuths				15 *d.* 0′.				30 *d.* 0′.			

Houres.		3.	9.	*Compl.*		4.	8.	*Compl.*		5.	7.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
66	0	17	29	72	31	12	33	77	27	6	34	83	26
	5		25	72	35		30	77	30		33	83	27
	10		21	72	39		27	77	33		31	83	29
	15		17	72	43		24	77	36		30	83	30
	20		13	72	47		22	77	38		28	83	32
	25		9	72	51		19	77	41		27	83	33
	30		5	72	55		16	77	44		25	83	35
	35		2	72	58		13	77	47		24	83	36
	40	16	58	73	2		10	77	50		22	83	38
	45		54	73	6		7	77	53		21	83	39
	50		50	73	10		5	77	55		19	83	41
	55		46	73	14		2	77	58		18	83	42
67	0		42	73	18	11	59	78	1		16	83	44
	5		39	73	21		56	78	4		15	83	45
	10		35	73	25		53	78	7		13	83	47
	15		31	73	29		50	78	10		12	83	48
	20		27	73	33		48	78	12		10	83	50
	25		23	73	37		45	78	15		9	83	51
	30		19	73	41		42	78	18		7	83	53
	35		16	73	44		39	78	21		6	83	54
	40		12	73	48		36	78	24		4	83	56
	45		8	73	52		34	78	26		3	83	57
	50		4	73	56		31	78	29		1	83	59
	55		0	74	0		28	78	32		0	84	0
68	0	15	57	74	3		25	78	35	5	58	84	2
	5		53	74	7		22	78	38		57	84	3
	10		49	74	11		20	78	40		55	84	5
	15		45	74	15		17	78	43		54	84	6
	20		41	74	19		14	78	46		52	84	8
	25		38	74	22		11	78	49		51	84	9
	30		34	74	26		9	78	51		49	84	11
	35		30	74	30		6	78	54		48	84	12
	40		26	74	34		3	78	57		46	84	14
	45		22	74	38		0	79	0		45	84	15
	50		19	74	41	10	57	79	3		43	84	17
	55		15	74	45		55	79	5		42	84	18
Azimuths		45 *d.* 0'.				60 *d.* 0'.				75 *d.* 0'.			

Houres		12		1. 11.		Compl.		2. 10.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
69	0	21	0	20	21	69	39	18	23	71	37
	5	20	55		16	69	44		19	71	41
	10		50		11	69	49		14	71	46
	15		45		6	69	54		10	71	50
	20		40		1	69	59		5	71	55
	25		35	19	56	70	4		2	71	58
	30		30		51	70	9	17	57	72	3
	35		25		47	70	13		52	72	8
	40		20		42	70	18		48	72	12
	45		15		37	70	23		43	72	17
	50		10		32	70	28		39	72	21
	55		5		27	70	33		34	72	26
70	0		0		22	70	38		30	72	30
	5	19	55		17	70	43		25	72	35
	10		50		12	70	48		21	72	39
	15		45		8	70	52		16	72	44
	20		40		3	70	57		12	72	48
	25		35	18	58	71	2		7	72	53
	30		30		53	71	7		3	72	57
	35		25		47	71	13	16	59	73	1
	40		20		42	71	18		54	73	6
	45		15		38	71	22		50	73	10
	50		10		34	71	26		45	73	15
	55		5		29	71	31		41	73	19
71	0		0		24	71	36		36	73	24
	5	18	55		19	71	41		32	73	28
	10		50		14	71	46		27	73	33
	15		45		9	71	51		23	73	37
	20		40		4	71	56		18	73	42
	25		35	17	59	72	1		14	73	46
	30		30		55	72	5		10	73	50
	35		25		50	72	10		5	73	55
	40		20		45	72	15		1	73	59
	45		15		41	72	19	15	56	74	4
	50		10		35	71	25		52	74	8
	55		5		30	72	30		47	74	12
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
69	0	15	11	74	49	10	52	79	8	5	40	84	20
	5		7	74	53		49	79	11		39	84	21
	10		4	74	56		46	79	14		37	84	23
	15		0	75	0		44	79	16		36	84	24
	20	14	56	75	4		41	79	19		35	84	25
	25		52	75	8		38	79	22		33	84	27
	30		49	75	11		35	79	25		32	84	28
	35		45	75	15		33	79	27		30	84	30
	40		41	75	19		30	79	30		29	84	31
	45		37	75	23		27	79	33		27	84	33
	50		33	75	27		24	79	36		26	84	34
	55		30	75	30		22	79	38		24	84	36
70	0		26	75	34		19	79	41		23	84	37
	5		22	75	38		16	79	44		21	84	39
	10		18	75	42		13	79	47		20	84	40
	15		15	75	45		11	79	49		19	84	41
	20		11	75	49		8	79	52		17	84	43
	25		7	75	53		5	79	55		16	84	44
	30		3	75	56		3	79	57		14	84	46
	35		0	76	0		0	80	0		13	84	47
	40	13	56	76	4	9	57	80	3		11	84	49
	45		52	76	8		54	80	6		10	84	50
	50		48	76	12		52	80	8		8	84	52
	55		45	76	15		49	80	11		7	84	53
71	0		41	76	19		46	80	14		6	84	54
	5		37	76	23		43	80	17		4	84	56
	10		34	76	26		41	80	19		3	84	57
	15		30	76	30		38	80	22		1	84	59
	20		26	76	34		35	80	25		0	85	0
	25		22	76	38		33	80	27	4	58	85	2
	30		19	76	41		30	80	30		57	85	3
	35		15	76	45		27	80	33		56	85	4
	40		11	76	49		24	80	36		54	85	6
	45		7	76	53		22	80	38		53	85	7
	50		4	76	56		19	80	41		51	85	9
	55		0	77	0		16	80	44		50	85	10

Azimuths 45 *d*. 0'. 60 *d*. 0'. 75 *d*. 0'.

Houres		12.		1.	11.	Compl.		2.	10.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
72	0	18	0	17	25	72	35	15	43	74	17
	5	17	55		20		40		38		22
	10		50		16		44		34		26
	15		45		11		49		29		31
	20		40		6		54		25		35
	25		35		1		59		20		40
	30		30	16	56	73	4		16		44
	35		25		51		9		11		49
	40		20		47		13		7		53
	45		15		42		18		3		57
	50		10		37		23	14	59	57	1
	55		5		32		28		54		6
73	0		0		27		33		50		10
	5	16	55		22		38		45		15
	10		50		17		43		41		19
	15		45		12		48		36		24
	20		40		8		52		32		28
	25		35		3		57		27		33
	30		30	15	58	74	2		23		37
	35		25		53		7		18		42
	40		20		48		12		14		46
	45		15		43		17		10		50
	50		10		39		21		6		54
	55		5		34		26		1		59
74	0		0		29		31	13	57	76	3
	5	15	55		24		36		52		8
	10		50		19		41		48		12
	15		45		14		46		43		17
	20		40		9		51		39		21
	25		35		4		56		34		26
	30		30		0	75	0		30		30
	35		25	14	55		5		25		35
	40		20		50		10		21		39
	45		15		45		15		17		43
	50		10		40		20		13		47
	55		5		35		25		8		52
Azimuths				15 d. 0'.				30 d. 0'.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
72	0	12	56	77	4	9	14	80	46	4	48	85	12
	5		52		8		11		49		47		13
	10		49		11		8		52		46		14
	15		45		15		5		55		45		15
	20		42		18		3		57		43		17
	25		38		22		1		59		42		18
	30		34		26	8	58	81	2		40		20
	35		30		30		55		5		39		21
	40		27		33		52		8		37		23
	45		23		37		49		11		36		24
	50		19		41		47		13		34		26
	55		15		45		44		16		33		27
73	0		12		48		41		19		31		29
	5		8		52		38		22		30		30
	10		5		55		36		24		29		31
	15		1		59		33		27		28		32
	20	11	57	78	3		31		29		26		34
	25		53		7		28		32		25		35
	30		50		10		26		34		23		37
	35		46		14		23		37		22		38
	40		42		18		20		40		20		40
	45		38		22		17		43		19		41
	50		35		25		15		45		17		43
	55		31		29		12		48		16		44
74	0		28		32		10		50		15		45
	5		24		36		7		53		14		46
	10		20		40		4		56		12		48
	15		16		44		1		59		11		49
	20		13		47	7	59	82	1		9		51
	25		9		51		56		4		8		52
	30		6		54		54		6		6		54
	35		2		58		51		9		5		55
	40	10	58	79	2		48		12		4		56
	45		54		6		45		15		3		57
	50		51		9		43		17		1		59
	55		47		13		40		20		0	86	0
Azimuths		45 *d*.0'.				60 *d*.0'.				75 *d*. 0'.			

Houres Latit.		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
75	0		0	14	31	75	29	13	4	76	56
	5	14	55		26		34	12	59	77	1
	10		50		21		39		55		5
	15		45		16		44		50		10
	20		40		11		49		46		14
	25		35		6		54		41		19
	30		30		2		58		37		23
	35		25	13	57	76	3		33		27
	40		20		52		8		29		31
	45		15		47		13		24		36
	50		10		42		18		20		40
	55		5		37		23		15		45
76	0		0		32		28		11		49
	5	13	55		27		33		6		54
	10		50		23		37		2		58
	15		45		18		42	11	58	78	2
	20		40		13		47		54		6
	25		35		8		52		49		11
	30		30		3		57		45		15
	35		25	12	58	77	2		40		20
	40		20		54		6		36		24
	45		15		49		11		31		29
	50		10		44		16		27		33
	55		5		39		21		22		38
77	0		0		34		26		18		42
	5	12	55		29		31		14		46
	10		50		25		35		10		50
	15		45		20		40		5		55
	20		40		15		45		1		59
	25		35		10		50	10	56	79	4
	30		30		5		55		52		8
	35		25		00		0		47		13
	40		20	11	56	78	4		43		17
	45		15		51		9		39		21
	50		10		46		14		35		25
	55		5		41		19		30		30
Azimuths				15 *d*.0'.				30 *d*.0'.			

Houres		3.	9.	*Compl.*		4.	8.	*Compl.*		5.	7.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
75	0	10	44	79	16	7	38	82	22	3	58	86	2
	5		40		20		35		25		57		3
	10		36		24		33		27		55		5
	15		32		28		30		30		54		6
	20		29		31		27		33		53		7
	25		25		35		24		36		52		8
	30		22		38		22		38		50		10
	35		18		42		19		41		49		11
	40		14		46		17		43		47		13
	45		10		50		14		46		46		14
	50		7		53		12		48		44		16
	55		3		57		9		51		43		17
76	0		0	80	0		6		54		42		18
	5	9	56		4		3		57		41		19
	10		53		7		1		59		39		21
	15		49		11	6	58	83	2		38		22
	20		45		15		56		4		36		24
	25		41		19		53		7		35		25
	30		38		22		51		9		33		27
	35		34		26		48		12		32		28
	40		31		29		45		15		31		29
	45		27		33		42		18		30		30
	50		24		36		40		20		28		32
	55		20		40		37		23		27		33
77	0		16		44		35		25		25		35
	5		12		48		32		28		24		36
	10		9		51		30		30		22		37
	15		5		55		27		33		21		39
	20		2		58		25		35		20		40
	25	8	58	81	2		22		38		19		41
	30		55		5		20		40		17		43
	35		51		9		17		43		16		44
	40		47		13		14		46		14		46
	45		43		17		11		49		13		47
	50		40		20		9		51		12		48
	55		36		24		6		54		11		49
Azimuths		45 *d.0'.*				60 *d.0'.*				75 *d.0'.*			

Houres Latit.		12.		1. 11.		*Compl.*		2. 10.		*Compl.*	
		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
78	0	12	0	11	36	78	24	10	26	79	34
	5	11	55		31		29		21		39
	10		50		26		34		14		43
	15		45		21		39		12		48
	20		40		17		43		08		52
	25		35		12		48		4		56
	30		30		7		53		0	80	0
	35		25		2		58	9	55		5
	40		20	10	57	79	3		51		9
	45		15		52		8		46		14
	50		10		48		12		42		18
	55		5		43		17		37		23
79	0		0		38		22		33		27
	5	10	55		33		27		29		31
	10		50		28		32		25		35
	15		45		23		37		20		40
	20		40		19		41		16		46
	25		35		14		46		11		49
	30		30		9		51		7		53
	35		25		4		56		2		58
	40		20	9	59	80	1	8	58	81	2
	45		15		54		6		54		6
	50		10		50		10		50		10
	55		5		45		15		45		15
80	0		0		40		20		41		19
	5	9	55		35		25		36		24
	10		50		30		30		32		28
	15		45		25		35		27		33
	20		40		21		39		23		37
	25		35		16		44		19		41
	30		30		11		49		15		45
	35		25		6		54		10		50
	40		20		1		59		6		54
	45		15	8	56	81	4		1		59
	50		10		52		8	7	57	82	3
	55		5		47		13		53		7
Azimuths				15*d*.0′.				30*d*.0′.			

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
78	0	8	33	81	27	6	4	83	56	3	9	86	51
	5		29		31		1		59		7		53
	10		26		34	5	59	84	1		6		54
	15		22		38		56		4		5		55
	20		18		42		54		6		4		56
	25		14		46		51		9		2		58
	30		11		49		49		11		1		59
	35		7		53		46		14	2	59	87	1
	40		4		56		43		17		58		2
	45		0	82	0		40		20		56		4
	50	7	57		3		38		22		55		5
	55		53		7		35		25		54		6
79	0		50		10		33		27		53		7
	5		45		14		30		30		52		8
	10		42		18		28		32		51		9
	15		38		22		25		35		49		11
	20		35		25		23		37		48		12
	25		31		29		20		40		46		14
	30		28		32		18		42		45		15
	35		24		36		15		45		43		17
	40		21		39		13		47		42		18
	45		17		43		10		50		40		20
	50		14		46		7		53		39		21
	55		10		50		4		56		38		22
80	0		6		54		2		58		37		23
	5		2		58	4	59	85	1		35		25
	10	6	59	83	1		57		3		34		26
	15		55		5		54		6		32		28
	20		52		8		52		8		31		29
	25		49		11		49		11		30		30
	30		46		14		47		13		29		31
	35		42		18		44		16		27		33
	40		38		22		42		18		26		34
	45		34		26		39		21		24		36
	50		31		29		37		23		23		37
	55		27		33		34		26		22		38
Azimuths		45 d. 0'				60 d. 0'				75 d. 0'			

Houres		12		1.	11.	*Compl.*		2.	10.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
81	0	9	0	8	42	81	18	7	49	82	11
	5	8	55		37		23		44		16
	10		50		32		28		40		20
	15		45		27		33		35		25
	20		40		23		37		31		29
	25		35		18		42		26		34
	30		30		13		47		22		38
	35		25		8		52		18		42
	40		20		3		57		14		46
	45		15	7	58	82	2		9		51
	50		10		54		6		5		55
	55		5		49		11		0	83	0
82	0		0		44		16	6	56		4
	5	7	55		39		21		52		8
	10		50		34		26		48		12
	15		45		29		31		43		17
	20		40		25		35		39		21
	25		35		20		40		34		26
	30		30		15		45		30		30
	35		25		10		50		26		34
	40		20		5		55		22		38
	45		15		0	83	0		17		43
	50		10	6	56		4		13		47
	55		5		51		9		8		52
83	0		0		46		14		4		56
	5	6	55		41		19	5	59	84	1
	10		50		36		24		55		5
	15		45		31		29		51		9
	20		40		26		34		47		13
	25		35		21		39		42		18
	30		30		17		43		38		22
	35		25		12		48		33		27
	40		20		7		53		29		31
	45		15		2		58		25		35
	50		10	5	57	84	3		21		39
	55		5		52		8		16		44
Azimuths				15 *d.* 0'.				30 *d.* 0'.			

Houres		3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
81	0	6	23	83	37	4	32	85	28	2	21	87	39
	5		19		41		29		31		19		41
	10		16		44		27		33		18		42
	15		12		48		24		36		17		43
	20		9		51		21		39		16		44
	25		5		55		18		42		14		46
	30		2		58		16		44		13		47
	35	5	58	84	2		13		47		11		49
	40		55		5		11		49		10		50
	45		51		9		8		52		9		51
	50		48		12		6		54		8		52
	55		44		16		3		57		6		53
82	0		41		19		1		59		5		55
	5		37		23	3	58	86	2		3		57
	10		33		27		56		4		2		58
	15		29		31		53		7		1		59
	20		26		34		51		9		0	88	0
	25		22		38		48		12	1	58		2
	30		19		41		46		14		57		3
	35		15		45		43		17		55		5
	40		12		48		41		19		54		6
	45		8		52		38		22		53		7
	50		5		55		36		24		52		8
	55		1		59		33		27		50		10
83	0	4	58	85	2		31		29		49		11
	5		54		6		28		32		48		12
	10		51		9		26		34		47		13
	15		47		13		23		37		45		15
	20		43		17		21		39		44		16
	25		39		21		18		42		42		18
	30		36		24		16		44		41		19
	35		32		28		13		47		40		20
	40		29		31		11		49		39		21
	45		25		35		8		52		37		23
	50		22		38		6		54		36		24
	55		18		42		3		57		34		26
Azimuths		45. *d.* 0'.				60 *d.* 0'.				75 *d.* 0'.			

Houres		12		1.	11.	*Compl.*		2.	10.	*Compl.*	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
84	0	6	0	5	48	84	12	5	12	84	48
	5		55		43		17		8		52
	10		50		38		22		3		57
	15		45		33		27	4	59	85	01
	20		40		28		32		55		05
	25		35		24		36		50		10
	30		30		19		41		46		14
	35		25		14		46		42		18
	40		20		9		51		37		23
	45		15		4		56		33		27
	50		10	4	59	85	01		29		31
	55		5		54		05		24		36
85	0	5	0		50		10		20		40
	5		55		45		15		16		44
	10		50		40		20		11		49
	15		45		35		25		7		53
	20		40		30		29		3		57
	25		35		26		34	3	58	86	02
	30		30		21		39		54		06
	35		25		16		44		50		10
	40		20		11		49		45		15
	45		15		6		54		41		19
	50		10		2		58		37		23
	55		5	3	57	86	03		32		28
86	0	4	0		52		08		28		32
	5		55		47		13		23		37
	10		50		42		18		18		42
	15		45		37		23		15		45
	20		40		33		27		11		49
	25		35		28		32		6		54
	30		30		23		37		2		58
	35		25		18		42	2	58	87	02
	40		20		13		47		53		07
	45		15		8		52		49		11
	50		10		4		56		45		15
	55		5	2	59	87	01		40		20
Azimuths					15.*d*.0'.				30*d*.0'.		

Houres		3.	9.	Compl.		4.	8.	Compl.		5.	7.	Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
84	0	4	15	85	45	3	0	87	7	1	33	88	26
	5		11	85	49	2	58	87	02		32	88	28
	10		8	85	52		55	87	05		31	88	29
	15		4	85	56		53	87	07		30	88	30
	20		1	85	59		50	87	10		28	88	32
	25	3	57	86	03		48	87	12		27	88	33
	30		54	86	06		45	87	15		26	88	34
	35		50	86	10		43	87	17		24	88	36
	40		47	86	13		40	87	20		23	88	37
	45		43	86	17		38	87	22		22	88	38
	50		39	86	20		35	87	25		20	88	40
	55		36	86	24		33	87	27		19	88	41
85	0		32	86	28		30	87	30		18	88	42
	5		29	86	31		28	87	32		17	88	43
	10		25	86	35		25	87	35		15	88	45
	15		22	86	38		23	87	37		14	8	46
	20		18	86	42		20	87	40		13	88	47
	25		15	86	45		18	87	42		11	88	49
	30		11	86	59		15	87	45		10	88	50
	35		8	86	52		13	87	47		9	88	51
	40		4	86	56		10	87	50		7	88	53
	45		0	87	00		8	87	52		6	88	54
	50	2	57	87	03		5	87	55		5	88	55
	55		53	87	07		3	87	57		3	88	56
86	0		50	87	10		0	88	00		2	88	58
	5		46	87	14	1	58	88	02		1	88	59
	10		43	87	17		55	88	05		0	89	00
	15		39	87	21		53	88	07	0	58	89	02
	20		36	87	24		50	88	10		57	89	03
	25		32	87	28		48	88	12		56	89	04
	30		29	87	31		45	88	15		54	89	06
	35		25	87	35		43	88	17		53	89	07
	40		21	87	39		40	88	20		52	89	08
	45		18	87	42		38	88	22		51	89	09
	50		14	87	46		35	88	25		49	89	11
	55		11	87	49		33	88	27		48	89	12
Azimuths						15 *d.* 0'.				30 *d* 0'.			

Houres Latit.		12. G.	M.	1. 11. G.	M.	Compl. G.	M.	2. 10. G.	M.	Compl. G.	M.
87	0	3	0	2	54	87	06	2	36	87	24
	5		55		49	87	11		32	87	28
	10		50		44	87	16		27	87	33
	15		45		39	87	21		23	87	37
	20		40		35	87	25		19	87	41
	25		35		31	87	29		14	87	46
	30		30		26	87	34		10	87	50
	35		25		20	87	40		6	87	54
	40		20		15	87	45		1	87	59
	45		15		10	87	50	1	57	88	03
	50		10		6	87	54		53	88	07
	55		5		1	87	59		48	88	12
88	0	2	0	1	56	88	04		44	88	16
	5		55		51	88	09		40	88	20
	10		50		46	88	14		35	88	25
	15		45		41	88	19		31	88	29
	20		40		37	88	23		27	88	33
	25		35		32	88	28		22	88	38
	30		30		27	88	33		18	88	42
	35		25		22	88	38		14	88	46
	40		20		17	88	43		9	88	51
	45		15		12	88	48		5	88	55
	50		10		8	88	52		1	88	59
	55		5		3	88	57	0	56	89	04
89	0	1	0	0	58	89	02		52	89	08
	5		55		53	89	07		48	89	12
	10		50		48	89	12		43	89	17
	15		45		43	89	17		39	89	21
	20		40		39	89	21		35	89	25
	25		35		34	89	26		30	89	30
	30		30		29	89	31		26	89	34
	35		25		24	89	36		22	89	38
	40		20		19	89	41		17	89	43
	45		15		14	89	46		13	89	47
	50		10		10	89	50		9	89	51
	55		5		5	89	55		4	89	56
Azimuths				15 *d.* 0'.				30 *d.* 0.			

Houres		3. 9.		Compl.		4. 8.		Compl.		5. 7.		Compl.	
Latit.		G.	M.	G.	M.	G.	M.	G.	M.	G.	M.	G.	M.
87	0	2	7	87	53	1	30	88	30	0	47	89	13
	5		4	87	56		28	88	32		44	89	16
	10		0	88	00		25	88	35		43	89	17
	15	1	57	88	03		23	88	37		43	89	17
	20		53	88	07		20	88	40		41	89	19
	25		50	88	10		18	88	42		40	89	20
	30		46	88	14		15	88	45		39	89	21
	35		43	88	17		13	88	47		37	89	23
	40		39	88	21		10	88	50		36	89	24
	45		35	88	25		8	88	52		35	89	25
	50		32	88	28		5	88	55		34	89	26
	55		28	88	32		3	88	57		32	89	28
88	0		25	88	35		0	89	00		31	89	29
	5		21	88	39	0	58	89	02		30	89	30
	10		18	88	42		55	89	05		28	89	32
	15		14	88	46		53	89	07		27	89	33
	20		11	88	49		50	89	10		26	89	34
	25		7	88	53		48	89	12		25	89	35
	30		4	88	56		45	89	15		23	89	37
	35		0	89	00		43	89	17		22	89	38
	40	0	57	89	03		40	89	20		21	89	39
	45		53	89	07		38	89	22		19	89	41
	50		50	89	10		35	89	25		18	89	42
	55		46	89	14		32	89	28		17	89	43
89	0		42	89	18		30	89	30		15	89	45
	5		39	89	21		27	89	33		14	89	46
	10		35	89	25		25	89	35		13	89	47
	15		32	89	28		22	89	37		12	89	48
	20		28	89	32		20	89	40		10	89	50
	25		25	89	35		17	89	42		9	89	51
	30		21	89	39		15	89	45		8	89	52
	35		18	89	42		12	89	47		6	89	54
	40		14	89	46		10	89	50		5	89	55
	45		11	89	49		7	89	52		4	89	56
	50		7	89	53		5	89	55		3	89	57
	55		4	89	56		2	89	57		1	89	59
Azimuths						15 *d.* 0′.				30 *d.* 0′.			

Many uſes might be made of this Table, which for brevity ſake I omit, and will only adde this, one how to make a table thereby of the heighth of the Sun for every houre and part of the day, in every degree and part of the Zodiack; which being neceſſary for contriving of Dials, upon all kind of Cylinders, Rings, Quadrants, and ſuch like (wherein the heighth of the Sun is required) may generally be ſupplyed for all latitudes, by this table, as in this example appeareth.

1 Set downe the ordinary houres before and after noone.

2 By them the complements of the houre arches of this table, as they are found in the common meeting of the houre and latitude, or heighth of the pole above the plane.

3 The Logarithmeticall ſines of thoſe arches, adding the Radius to the Log. ſine of the latitude.

4 Subduct the Log. ſine of each arch, out of the Log. ſine of the latitude, and there ſhall come forth the Log. ſines of other arches, which reſerve to be added as followeth.

5 Vnder the complements of the houre arches aforeſaid, ſet the declinations of the Sun in the beginning of each ſigne, or of any part of the ſigne, if you will proceed to parts.

6 Subtract theſe declinations (beginning with 12) out of the complements of the houre arches (or contrary when there is cauſe) for Northerne ſignes, and adde them for Southern ſignes, ſo have you new arches anſwerable to each houre in every ſigne.

7 The Log. coſines of theſe arches added to the Log. ſines reſerved aboveſaid, beget new Log. ſines, which found in the Canon, afford the true altitudes of the Sun for each houre deſired; only the Log. Coſine of 12 gives the heighth without correction.

8 Laſtly, the complements of the arches proper to the Log. ſines reſerved, which helped to find the altitudes of the Sun in the reſt of the Zodiacke, are the very altitudes themſelves of the Sun above the Horizon in ♈ and ♎, all which being collected into a table (as here is done) it is ready for uſe; and note that when there is cauſe to uſe more houres then ſix, equall houres from ſix, have equall arches, and Logarithmes belonging to them.

Houres

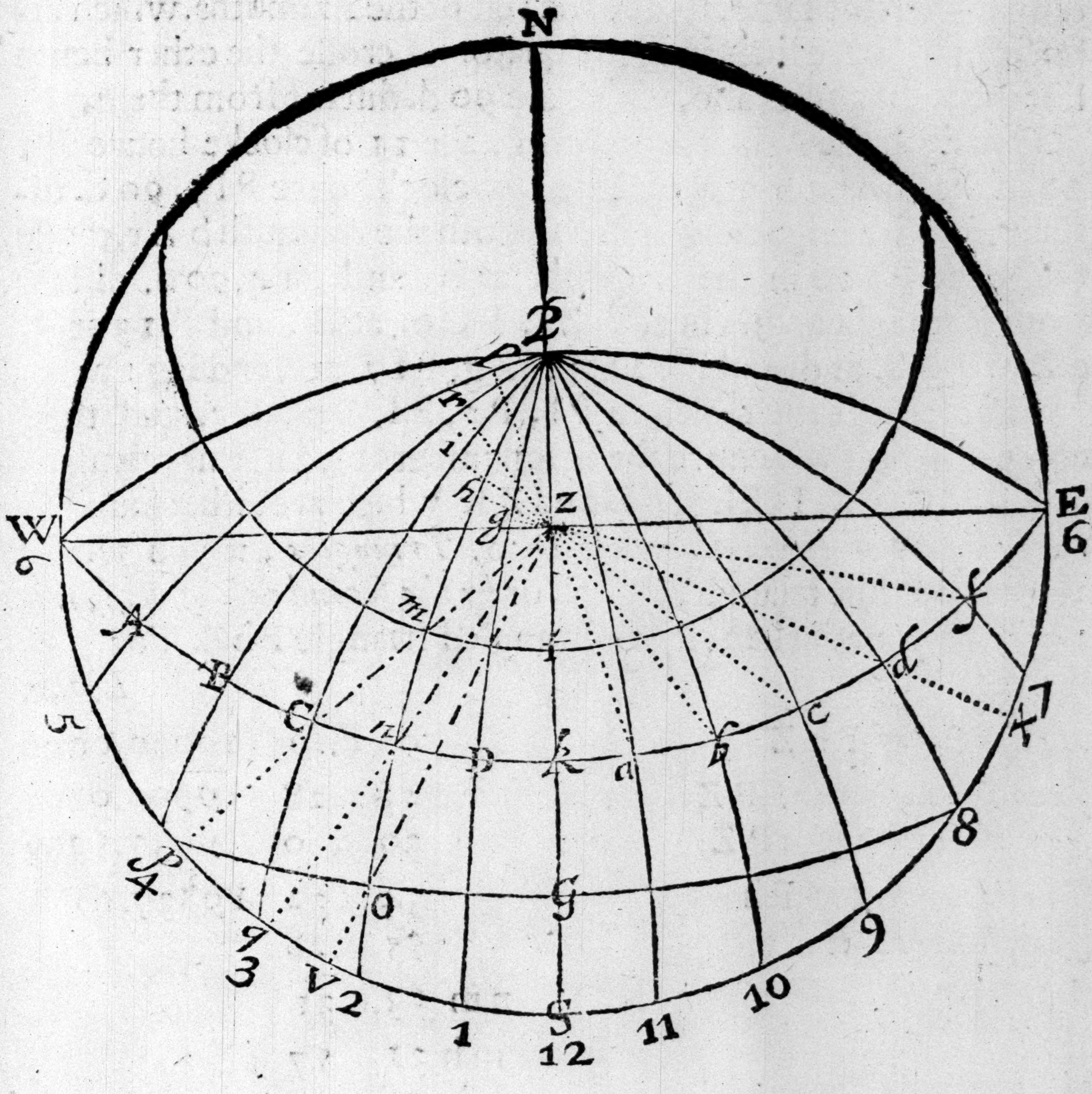
Houres before & after noone.		*Comple: of the arches in thetable*		*The Logarithmes of their sines.*	*New Log: found by subduction andreserue*	*Heighth of the Sun for each houre in every signe.*			
H.	H.	d	'			d	♈ o'	Houres.	
12	0	51	32	19893.74					
11	1	52	30	9899.47	9994.27	9	17	7	5
10	2	55	28	9915.82	9977.92	18	7	8	4
9	3	60	41	9940.41	9953.33	26	5	9	3
8	4	68	20	9968.18	9925.56	32	36	10	2
7	5	78	23	9991.01	9902.73	36	56	11	1
6	6	90	0	10000.00	9891.74	38	28		
5	7	101	37	9991.01	9902.73	♎		12	
4	8	111	40	9968.18	9925.56				
♋ ♑		23	31	*The declinations of the Signes.*					
♊ ♐ ♌ ♒		20	13						
♉ ♏ ♍ ♓		11	31						
		d	'	*Cosines*		d	'	*Houres.*	
		28	1	9945.87		61	59	12	
		28	59	9941.89	9936.16	59	41	11	1
		31	57	9928.66	9906.58	53	45	10	2
♋		37	9	9901.49	9854.82	45	43	9	3
Subtr.		44	49	9850.87	9776.43	36	42	8	4
		54	52	9760.03	9662.76	27	23	7	5
		66	29	9600.99	9494.73	18	12	6	6
		78	6	9314.30	9217.03	9	29	5	7
		88	9	8508.97	8434.53	1	34	4	8
		31	19	9931.61		58	41	12	
		32	17	9927.07	9921.34	56	33	11	1
		35	15	9912.03	9889.35	50	55	10	2
♊ ♌		40	27	9881.37	9834.70	43	7	9	3
Subtr.		48	7	9824.53	9750.09	34	14	8	4
		58	10	9722.18	9624.91	24	56	7	5
		69	47	9538.54	9432.28	15	42	6	6
		81	24	9174.74	9077.47	6	52	5	7

	40	1	9884	15			49	59	12	
	40	59	9877	89	9872	16	48	10	11	1
	43	57	9857	30	9835	22	43	11	10	2
♉ ♍	49	9	9815	63	9768	96	35	59	9	3
Subtr.	56	49	9738	24	9663	80	27	28	8	4
	66	52	9594	25	9496	98	18	18	7	5
	78	29	9300	27	9194	01	9	0	6	6
	63	3	9356	30			26	57	12	
	64	1	9641	58	9635	85	25	37	11	1
♏ ♓	66	59	9592	17	9570	09	21	49	10	2
Add.	72	11	9485	68	9439	01	15	57	9	3
	79	51	9246	07	9171	63	8	32	8	4
	89	54	7241	88	7144	61	0	05	7	5
	71	45	9495	77			18	15	12	
	72	43	9472	90	9467	17	17	3	11	1
♐ ♒	75	41	9393	19	9371	11	13	36	10	2
Add.	80	53	9199	88	9153	21	8	11	9	3
	88	33	8403	20	8328	76	1	13	8	4
	75	3	9411	58			14	57	12	
♑	76	1	9383	17	9377	44	13	48	11	1
Add.	78	59	9281	25	9259	17	10	28	10	2
	84	11	9005	80	8959	13	5	13	9	3

Table of the altitude of the Sun for every houre of the day, in the beginning of each signe. Lat'e. 51.d 32'.

Houres	12	11	10	9	8	7	6	5	4	
Houres		1	2	3	4	5	6	7	8	
	d '	d '	d '	d '	d '	d '	d '	d '	d '	
♋	61.59	59.41	53 45	45.53	36.42	27.23	18.12	9 29	1.34	♋
♊	58.41	56.33	50.55	43. 7	34.14	24.56	15.42	6 52	0	♌
♉	49.59	48.10	43.11	35.59	27.28	18.18	9 0	0		♍
♈	38.28	36.56	32.36	26. 5	18 7	9.17	0 0			♎
♓	26.57	25.37	21.49	15.57	8.32	0 5				♏
♒	18.15	17. 3	13.36	8.11	1.13					♐
♑	14.57	13.48	10.28	5.13						♑

To



To prove the truth of this calculation, which affordeth with so great facilitie the heighth of the Sunne in any signe or part for any houre or part of the day, let the Horizon, Æquator, Tropiques, and houre lines be drawne, parts of the generall Scheme, as is directed in the fourth Chapter; crosse the houre lines with those Azimuths, which intersect them at right angles, which is easily done, seeing you have two points, the one in the Æquator, the other in the Zenith, 'ready given to draw them by; for such is the harmony of the Sphericks in generall, but particularly of Azimuths and Houre circles, that as the South Azimuth coincident with the Meridian doth crosse the 12 of clock houre in

the Æquator, and the six of clocke houre at right angles, 90 d. distant from the same, so doe the rest of the Azimuths, which intersect the houre lines in the Æquator, crosse the other houre lines at right angles also, which are 90 d. distant from them.

Thus doth the Azimuth a z l crosse the 11 of clocke houre P a 11 in the Æquator at a, and the 5 of clock houre P l 5. 90 d. distant from it at right angles in l, so doth the Azimuth b Z r, crosse the houre P b 10 in the Æquator at b, and P r 4, 90 d. distant from it at right angles in r, C Z I, P C 9, at C, and P I 3 at I, d Z h, P d 8, at d, and P h 2 at h. f Z g, P f 7, at f, and P g 1 at g.

The arches in the table are P l, P r, P I, P h, &c. and their complements (which are the first numbers used in this calculation) are l A, r B, I C, h n, g D and Z K which are either found *by the first part of the ninth case of O. S. Triangles*, if you worke with the obtuse triangle, P Z N, or *by the second case of R. S. triangles*, if you worke with right angled triangle P h Z. For

			Logar.
As the sine of P h Z	90 *d.*	0	10000.0000
Js to the tangent of P Z	38	28	9900.0865
So is the cosine of h P Z	30	0	9937.5306
To the tangent of P h	34	32	19837.6171
Complement h n	55	28	
n m	23	31	
m h	31	57	
o h	78	59	

Substract n m 23 d. 31′. out of h n 55 d. 28′. there resteth m h 31 d. 57′. for 2 of clock in ♋, but adde n m or n o 23 d. 31′. unto h n 55 d. 28′. so have you h o 78 d. 59′. for 2 of clocke in ♑, and thus are all the rest of the numbers made up in the second colume of the Table, by adding and subtracting the declinations proper to them.

The first 9 numbers of the 3 colume are the Logarithmeticall Sines of the arches formerly found, only to the Logarithmes of 51 d. 32′. the elevation of the Pole, the Radius is alwayes to be added.

The first 8 numbers of the fourth colume are found by conti-

nuall

nuall subtraction of those Logarithmes out of the Logarithme of the elevation of the Pole; so if you subduct 9915.82. proper to 10 and 2 of clock out of 19893.74. the Radius and elevation, there resteth 9977.92. the complement of the heighth of the Sun in ♈ or ♎ for 8 and 4 of clock, for in the Triangle n h d, *by the 15 of the 4 of Regiomontanus*.

			Logar.
As the sine of n h	55 *d.*	28′.	9915.8199
Is to the sine of h d	90	0	10000.0000
So is the sine of K Z	51	32	9893.7452
To the sine of Z d	71	53	9977.9253

The complement whereof Z h 18 d. 7′. equall to d x, is the altitude of the Sun in the Æquator at 8 or 4 of clocke 90 d. distant from P h n 2 of clock, and so of any other.

The rest of the numbers in the 3 Colume are the Logarithmeticall Cosines of the arches of the second Colume, which continually added to the Logarithmes of the fourth Colume, proper to the heighth of the Sun in the Æquator formerly found, doe make up the rest of the Logarithmeticall Sines of the fourth colume, which found in the Canon, give the altitudes desired, as may be likewise proved out of the Scheme by the triangles Z h m, Z h n, and Z h O, *by the ninth case of R.S. Triangles.* For

			Logar.
As the sine of Z h m *or* Z h O	90 *d.*	0′.	10000.0000
Is to the cosine of h m	31	57	9928.6570
Or h O	78	59	9281.1482
So is the cosine of Z h	18	7	9977.9253
To the cosine of Z m	36	15	9906.5823
Or Z O	79	32	9259.0735

Therefore m p 53 d. 45′. the complement of Z m, is the altitude of the Sunne for 10 and 2 of clocke in ♋, and O V 10 d. 28′. the complement of Z O, for the same houres in ♑, the

thing

thing desired, and thus may the calculation be proved out of the same Scheme for all the rest of the houres also.

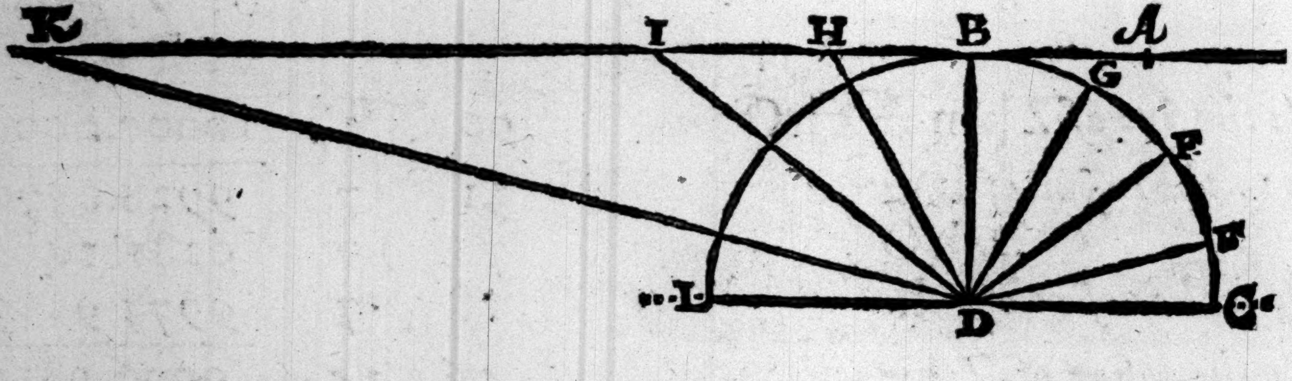
CHAP. XXXIV.

To draw a Diall upon the seeling of a Roome.

I Will now conclude this worke with a conceit of *Sconbergius*, who hath also borrowed the same from *Babtista benedictus: viz.* how to draw a Diall upon the seeling of a Roome, whereby we may see the houre of the day, by the reflected beames of the Sun, as we sit within doores. I confesse it is a pleasant thing, to behold how Art hath taught the Sun to trace out those lines and paralels by reflection from a glasse, which the direct beames can never shine upon.

The Demonstration.

The reason thereof is grounded upon that axiome of *Euclide* in his *Catoptriques*: that the angles of Incidence and Reflection are evermore equall; as may appeare by this Diagram.



Let A B K represent the seeling, L D C the Horizontall plane, passing thorough the glasse at D: D B the distance from the glasse to the seeling; upon the Radius D B draw the semicircle L B C, representing the Merdian: let E be the altitude of the Sun in ♑ 14 d. 57'. F in the Æquator 38 d. 28'. and C in ♋, 61 d. 59', by

by the former axiome the Sunne in G casts his beames upon the glasse in D, which reflects them backe againe to H: in F it reflects to I: in E to K: making the angles H D B, equall to G D B, I D B to F D B, and K D B to E D B. Now if D B be made the Radius, then shall A B K be a tangent line to it: and the points H, I, K, upon the seeling may be easily found by the naturall tangents of the Complements of the angles aforesaid; and the same reason holdeth upon every other houre circle, as well as upon the Meridian.

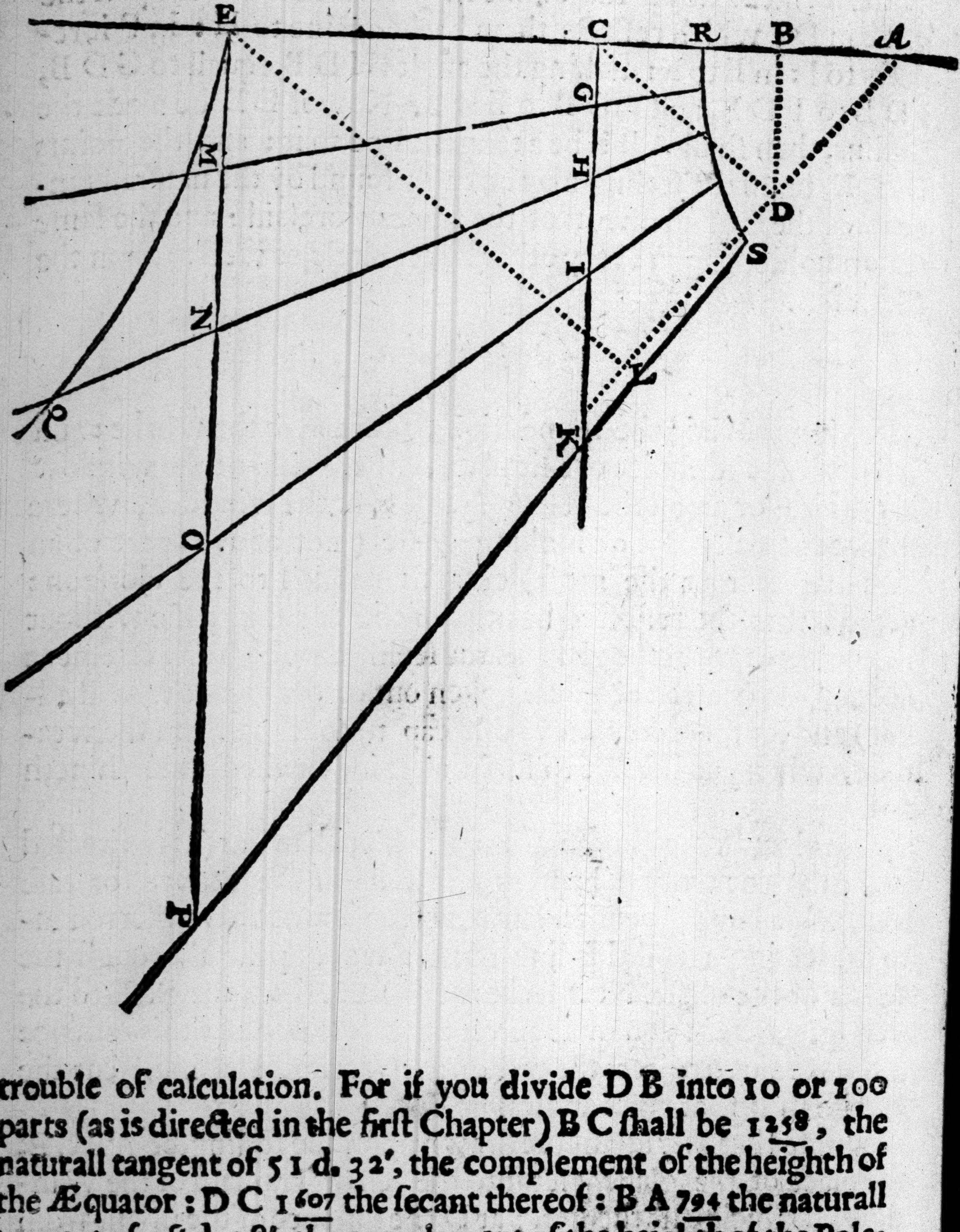
The projection.

Having thus laid the foundation, proceed to the worke: and first of all make choice of a fit place, either without the window in the aire; or upon the Sell or Transam of the window, where to place a small piece of looking glasse (not above ¼ part of an inch diameter at the most) exeactly paralell to the Horizon: yet so, that the reflected beames of the Sun may passe without impediment from the glasse to the seeling, (which any casement opened, or quarrell of glasse taken out of the window will admit) and let there be a moveable cap to cover it from the weather, when you list not to looke after it, or the Sunne shineth not.

The place being chosen, draw the Meridian line (as is directed in the sixth or tenth Chapters) first upon the flowre for ease sake, which by perpendicnlars may afterwards be transferred into the seeling: and this line must alwayes passe thorough the center of the glasse. Next seeke the distance from the glasse to the seeling, wherein you must be very accurate, because this distance is the Radius to direct the rest of the worke, and must cut the Meridian line at right angles.

Suppose that Meridian line drawn upon the seeling, be A B C E, the place of the glasse (let into the Sell or Transam of the Window the thicknesse thereof,) at D the distance of the Glasse from the Seeling D B, make D B the Radius, then shall A C E be a tangent line thereto: and the severall points A, R, C, E, upon the Meridian, are easily found, by naturall tangents, without the

trouble



trouble of calculation. For if you divide D B into 10 or 100 parts (as is directed in the first Chapter) B C shall be 1258, the naturall tangent of 51 d. 32′, the complement of the heighth of the Æquator: D C 1607 the secant thereof: B A 794 the naturall tangent of 38 d. 28′, the complement of the heighth of the Pole; and A the center of the Diall, where all the houre lines will meet abroad in the aire, if we had any need thereof: B R 532 the naturall

turall tangent of 28 d. 1′, the complement of the heighth of the Sun in ♋, and B E 3745 the naturall tangent of 75 d. 3′. the complement of the heighth of the Sun in ♑.

Thorough the point C draw the line CK at right angles to the Meridian, representing the Æquator upon the ſeeling: make C D the Radius of the Æquator, then ſhall C K be a tangent line thereunto: divide C D into 10 or 100 parts as afore, then ſhall C G be 268 of thoſe parts, the naturall tangent of 15 d. for 11 and 1 of clocke, and C H 577, the naturall tangent of 30 d. for 10 and 2 of clocke: and C I 1000 equall to the Radius, the naturall tangent of 45 degrees for 9 and 3 of clocke: and C K 1732, the naturall tangent of 60 degrees for 8 and 4 of clocke, if the houres and 7 and 5 of clocke will not fall conveniently upon the ſeeling, they muſt bee ſupplied from an Eaſt and Weſt window.

Having found the point G, H, I, K, upon this Æquinoctiall, thorough which the houre lines muſt paſſe: you may draw another paralell unto it, from any part of the Meridian where you will. Let that line be E P, drawne from the interſection of ♑, and the Meridian: from the point E raiſe a perpendicular to the axis A D continued to L, which will be paralell to C D, if there be no errour in the worke. Make E L a new Radius, which divide into 10 or 100 parts as afore, then ſhall E P be a tangent line thereunto; and the ſame naturall tangents, taken of this line divided, as formerly they were of C D, ſhall give the diſtances of M N O P from the Meridian, correſpondent to the former: by each two points G M, H N, I O, and K P, draw ſtreight lines: ſo ſhall you have the true houre lines, for the reflected beames of the Sun without any regard to the centre, which fals without the roome in the aire.

If you be deſirous to draw the paralels of the Signes, (thoſe two of ♋ and ♑ being neceſſary, for confining the length of the houre lines) or the diurnall arches, Almicanters, and the like, you have directions for them in the 27. 28 and 30 Chapters aforeſaid, but if you will worke by the complements of the Suns altitude, make D B the Radius againe, the diſtance of the glaſſe and ſee-

seeling representing the perpendicular stile of the Horizontall. Then shall you find the altitudes of the Sun ready calculated in the end of the former Chapter, for every signe, and houre of the day: the naturall tangents of the Complements whereof taken of the same line ~~diuided as afore, and set from B representing the foote of the perpendicular stile~~, upon each houre line divided as afore, and set from B representing the foot of the perpendicular stile, and E Q are drawne, for ♋ ♑; you have the paralells desired.

The like may be done, upon any erect plane, South, North, East, West, or declining; alwayes placing the glasse the length of the pependicular stile, from the plane, supposed to be in the center of the earth.

And note that if you first draw the Diall in paper to your liking; you may (by helpe of a foot, divided into ten parts, and $\frac{1}{10}$ thereof by Diagonals into 100) transferre the same into the seeling, as was desired.

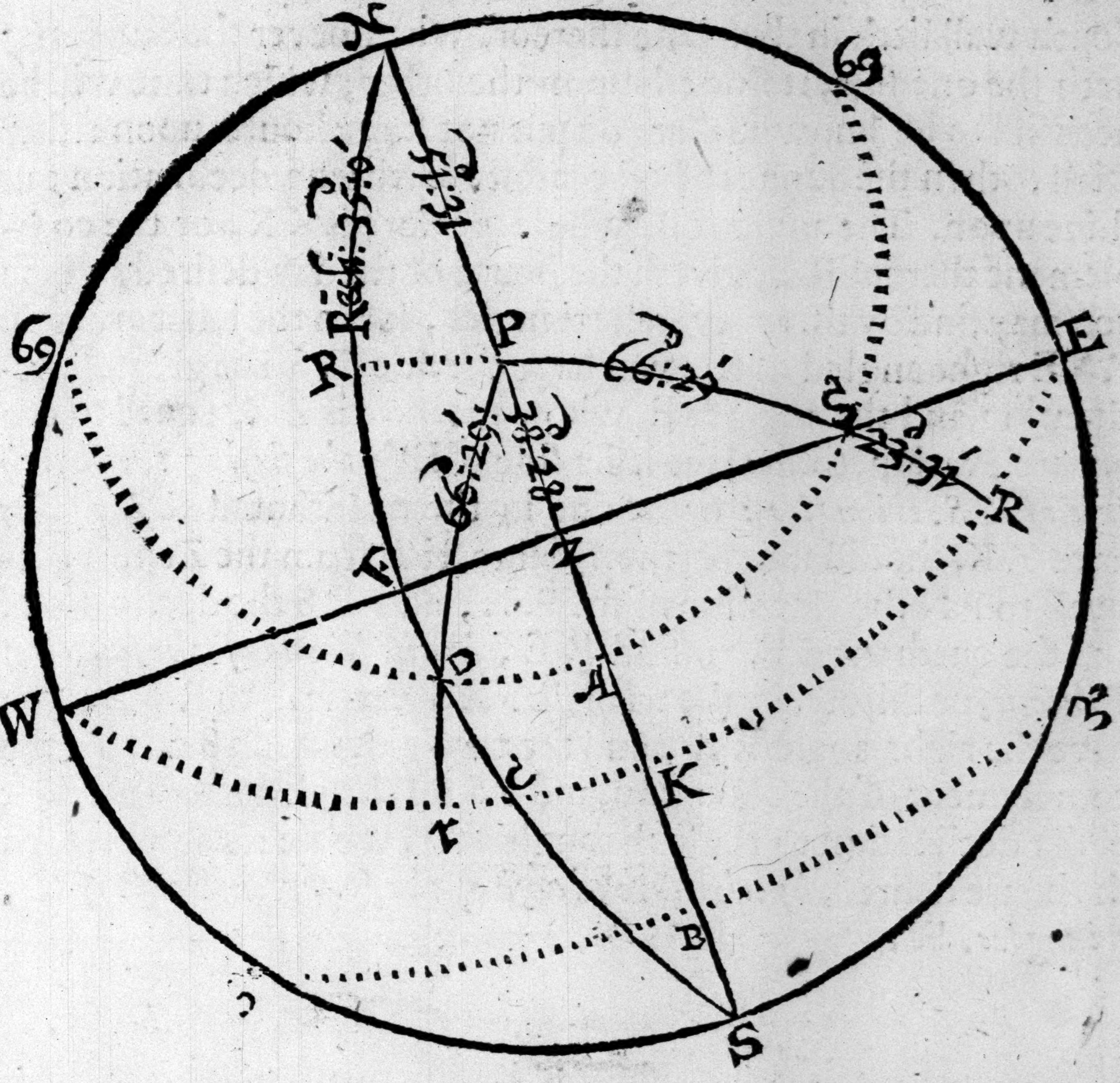
CHAP. XXXV.

Divers propositions necessary for Dialling.

PROPOSITION I.

The elevation of the Pole, and declination of the Sunne being given, to find at what houre the Sun passeth from the one side of the Prime verticall to the other.

AS the Spheare it selfe may be severall wayes projected in *plano*, so may the particular parts thereof necessary for this purpose; the usuall way is by making the limbe, or outward circle, to be the Meridian; so the face of the Scheme representeth the East or West Hemisphere: but



I rather retaine my first forme, which making the Horizon to be the limbe, the face thereof representeth the upper or nether Hemisphere, and wil serve much apter for this purpose) resolving all the Propositions following by right angled Triangles alone, with the helpe of the heighth of the stile, and angle of the Meridian, which must of necessitie be first found, before any Diall can be made.

To resolve this question therefore, you may remember that NESW is the Horizon, NZS the Meridian, EZW the prime verticall, ♋A♋ the Tropique of Cancer, EKW the Equinoctiall, ♑B♑ the Tropique of Capricorne, P the North Pole, and Z the Zenith, PSR a Meridian, or houre Circle crossing the Tropique of ♋ in the point S upon the prime Verticall: seeing then that every North and South

wall

South wall lieth in the plane thereof, whensoever the Sun forsaketh the one side, it shineth upon the other; which time will be needfull to be knowne that you put not more houres upon either Diall, then the Sunne in his greatest Northerne declination can shine upon. The angle at P, whose measure is K R, or the complement thereof R E, giveth the houre of the day desired, which you may find by three severall triangles, for in the lesser triangle R S E right angled at R, you have the side R S the greatest declination, and the angle at E, whose measure is Z K, equall to the poles elevation, to find the lesser side R E *by the first of the fourth case of R.S. triangles*: or againe in the quadrantall K Z E you have Z K, the distance of the Equinoctiall from the Zenith, equall to P N the elevation of the Pole, and R S the declination, and the quadrant K E, to find R E, *by the second of the fourth of Pitiscus*, or thirdly, in the triangle P Z S verticall to R S E, you have the right angle at Z, and the two sides P Z 38 d. 28'. the complement of the elevation, and P S *66* d. *29'*. the complement of the declination to finde the angle at P, whose measure is K R, the houre desired, *by the second case of the fourteenth case of R.S. triangles*. For

			Logar.
As the tangent of P S	*66 d.*	*29'.*	10361.35
Is to the sine of P Z S	90	0	10000.00
So is the tangent of Z P	38	28	9900.08
To the sine of Z S P	20	14	X9538.73
Therefore Z P S	*69 d.*	*46'.*	

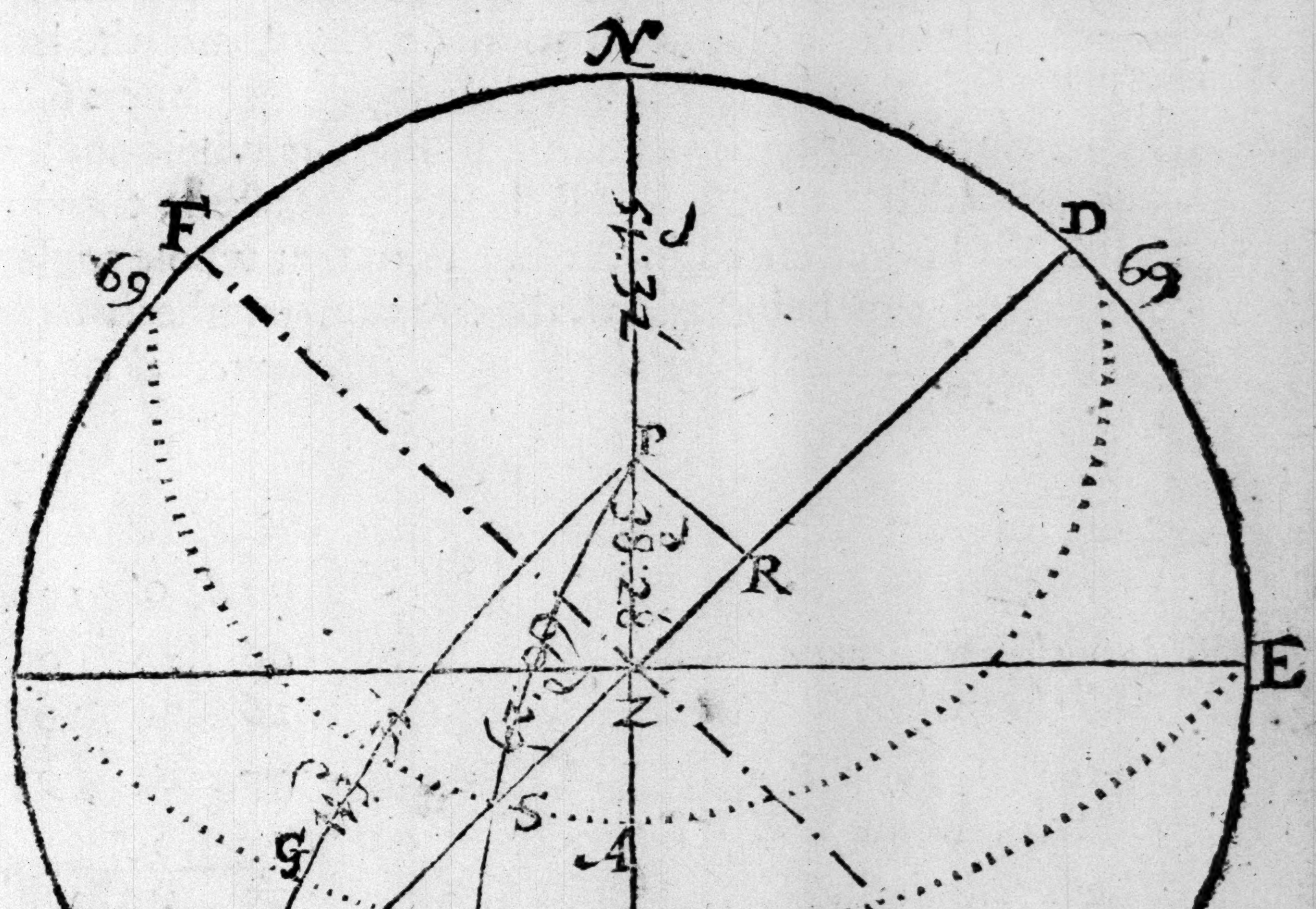
Which *69* degrees *46'*. resolved into time, giveth foure houres 39'. for K R, reckoning from the Meridian, or the complement thereof 1 houre 21 for R E, accompting from the prime verticall or houre of six. Now then because the Sunne forsaketh the North wall 21'. after 7 in the morning, and returneth to it againe 21'. before 5 at night, it is needlesse to put upon that Diall 8 of clocke in the morning, or 4 at night, either of which houres the Sun can never shine upon in our latitude.

PRO-

PROPOSITION II.

The elevation of the Pole, and declination of the Sun being given, to find what time the Sun shall part from the one side of any declining plane to the other side thereof.

ALL erect planes declining lie under the azimuth of their declination; therefore let C Z R D be a declining plane, 45 degrees from E or W, as much as the Poles thereof H and F decline from the North and South parts of the Meridian N and S, cutting the tropiques of ♋ and ♑ in the points



S and C; and let P C, and P S, be two Meridians, or houre circles drawne from the Pole, crossing the tropiques upon the plane in the said points of C and S; the angles C P Z and S P Z, shall give the houres of the day, (whose measures upon the Æquator are æ K, and æ G) when the Sun in each tropique forsaketh the one side of the Decliner, to shine upon the other; which you may find by the two oblique triangles C P Z, and S P Z (wherein two sides and an angle adjacent are given) *by the tenth case of O.S. triangles.* But by helpe of the angle between the two Meridians Z P R, and the heighth of the Pole above the plane P R (which must alwayes be found before you can make the Diall) you shall easily resolve this and the like questions by the right angled triangles S R P, and C R P: for in the first you have the right angle at R *90* d. o'. and the base opposite thereto P S, the complement of the declination *66* d. *29'*. and the lesser side P R the heighth of the stile, or Pole above the plane *26* d. *6* (as in the ninth Chapter appeareth) to find the whole angle S P R, out of which the angle Z P R being subtracted, there resteth S P Z, the houre desired in ♋: but unto that whole angle S P R, the angle Z P R being added, the complement thereof to 180 d. giveth the houre in ♑, *by the second of the fourteenth case of R.S. triangles.* For

			Logar.
As the sine of S R P	*90 d.*	o'	10000.00
Is to the cotangent of P S	66	29	9638.65
So is the tangent of P R	26	6	9690.10
To the cosine of S P R	77	41	19328.75
Subtract the angle *Z P R*	51	57	
There resteth *S P Z*	25	44	which re-

solved into time giveth one houre 43'. for the time in ♋.

Againe unto the angle *S P R*	77	41'.	
Adde the angle *Z P R*	51	57	
There ariseth an angle of	129	38	
Whose complement to 180 d. is	50	22	converted into

into time, giveth 3 houres 21′. ½ for the time in ♑, when the Sun passeth from one side of the plane to the other; betweene which two limits the annuall varietie of the Sunne is concluded, wherefore you may put upon any Diall declining East 45 d. the houre of 3 of clocke, and declining West as much the houre of 9 of clocke, and a ¼ if you will, at which times the Sunne passeth to their opposite sides. And seeing by this calculation it plainly appeareth that the Sunne keeping the way of the Ecliptique precisely, may notwithstanding vary an houre and almost ¾ of time upon the same azimuth of Southeast or Southwest, upon which the Moone here at *London* maketh full Sea, both at full & change; which yet in respect of her latitude may alter the time more, let them that prescribe rules for the tydes consider how seldome the Moone commeth upon the S. W. or S. E. azimuthes just at the houres of 3 or 9, and regulate the times thereof accordingly.

PROPOSITION III.

The elevation of the Pole, declination of the Sun, and reclination of the Plane being given; to find what time the Sun forsaketh an E. or W. reclining plane, and shineth upon the inclining opposite thereto.

THe planes of East and West recliners or incliners lye in the circle of position denominating their reclination: Let that circle be S F N of the first Scheme, reclining from the Zenith upon the prime verticall E Z W the quantity of Z F 35 d. cutting the tropique of ♋ in the point D: and let the houre circle passing by the place of the Sun be P D R, intersecting the tropique and the plane in the same point D: the angle D P A, whose measure is r K, shall give the houre, when the Sun passeth from the upper face of the reclining plane, to the opposite the inclining and nether face thereof; which you may find by the quadrantall F Z S, and the verticall triangles C K S,

and

and C r D : K C and C r measuring the angle at P, *by the first of the fift case of R.S. triangles*, but I rather resolve it by the right angled triangle D R P, having (*by the eleventh Chapter*) the angle R D N between the Meridians, and the side R P, the heighth of the stile above the plane, readie calculated; wherefore P D being 66 d. 29′. and P R 26 d. 41′. I say *by the second of the fourteenth case of R.S. triangles*.

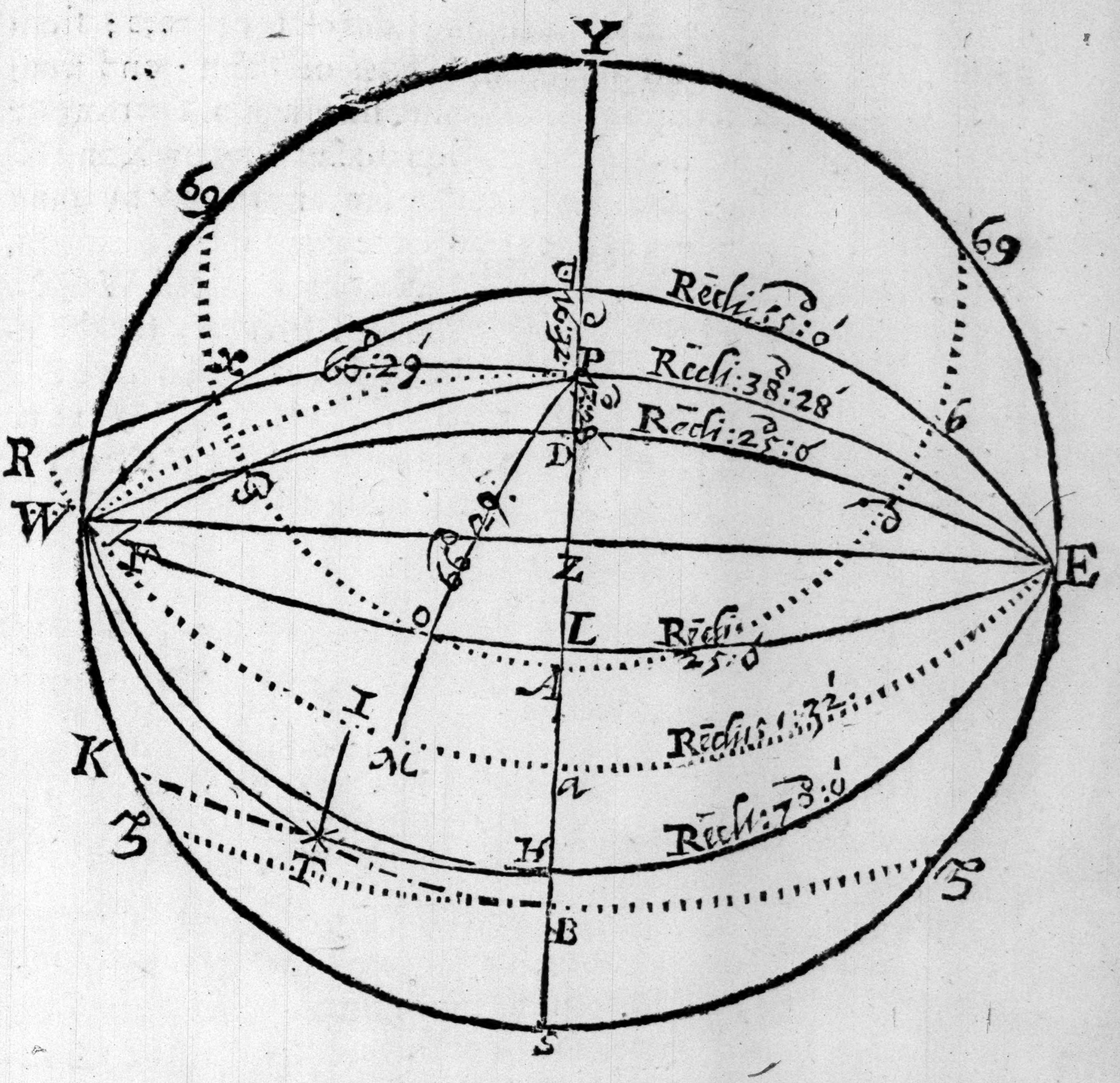
			Logar.
As the sine of P R D	90 d.	0′.	10000.00
Is to the cotangent P D	66	29	9638.65
So is the tangent P R	26	41	9701.21
To the cosine of D P R	77	22	19339.86
Unto which adde the angle R P N betweene the two Meridians	66	28	
There ariseth the angle D P N	143	50	
Whose complement to 180 d. giveth the angle D P Z	36	10	

Which 36 d. 10′. resolved into time, giveth 2 houres 24′.½ afternoone, when the Sun in the tropique of ♋ forsaketh the East reclining 35 d. and illuminateth the opposite the West inclining plane as much, or it giveth 2 houres 24′½ before noone, when the Sunne parteth from the East inclining plane, and enlighteneth the West reclining as much.

PROPOSITION IV.

The altitude of the Pole, declination of the Sun, and reclination of the plane being given, to find what time the Sun shall forsake a North inclining plane, to shine upon the South reclining opposite thereto.

THere are six varieties of North and South reclining and inclining planes, as by the 12 Chapter more at large doth appeare: of the three South that which reclineth to the Pole, lyeth in the six of clock houre circle, represented in the scheme by



by the line E P W, and therefore the case is plane, that the Sunne alwayes passes from one side of the flat to the other, just at 6 of clock; and in the Southerne signes shines not at all upon the inclining side. The like may be said of E a W, the North reclining plane to the Equinoctiall; for during the time of the Sunnes abode in the Northerne signes, it onely shines upon the reclining part in the Southerne signes upon the inclining part thereof, but the times of the rest are thus to be found. The South reclining 55 degrees, represented by the circle E C X W, cutteth the tropique of ♋ in two places at X and B, so doth the South reclining 25 d. represented by E D G W, intersect it twice at G and d, by which

it

it plainly appeareth, that from the Suns rise in ♋, till he come to b and d, he shineth upon the inclining sides of the planes; from thence to G and X upon the reclining sides of them; and from those points till he set upon the inclining sides again. Therfore let fall two Quadrants from P to the Æquator, passing by X and G, *viz.* P X R and P G F, the like should be drawne from P by b and d, but to auoid confusion of lines; so have you foure Triangles, to determine the same by, either P C X or his verticall W R X, for the first case: and D P G, or his verticall F W G, for the second case. In the triangle P C X, right angled at C, you have P C the heighth of the pole above the reclining plane E C W 16 d. 32′. as *pag.* 148. and the base P X, the complement of the declination 66 d. 29′. to find the angle at P: wherefore *by the second of the 14 case of R.S. triangles.*

			Logar.
As the sine of P C X	90 d.	0′.	10000.00
Is to the cotangent P X	66	29	9638.65
So is the tangent P C	16	32	9472.53
To the cosine of C P X	82	35	X9111.18

Subtract C P X 82 d. 35′. out of N P W 90 d. there remaynes R P W. or E P b 7 d. 25′. which converted into time giveth o houres 30′. before 6 of clock in the morning, and after 6 at night, when the Sun in ♋ departs from the inclining side of the plane, and shines upon the reclining and contrary. In like manner, in the triangle D P G, you have P G, the same with P X, 66 d. 29′. and P D the heighth of the South Pole above the reclining plane E D W, 13 d. 28′. as *pag.* 144. and the right angle at D, to find the angle P, wherefore by the same case.

			Logar.
As the sine of P D G	90 d.	0′.	10000.00
Is to the cotangent P G	66	29	9638.65
So is the tangent P D	13	28	9379.24
To the cosine of G P D	84	2	X9017.89

Sub-

Subtract G P D 84 d. 2′. out of a P W 90 d. there remaynes W P F or E P d, 5 d. 58′. which converted into time, giveth 0 houres 24′, after and afore 6 of clock, when the Sunne in ♋ forſakes the inclining ſide of that plane, to illuminate the oppoſite, the reclining part thereof, and contrary. And thus may you be ſatisfied for any other declination of the Sun whatſoever.

PROPOSITION V.

The altitude of the pole, declination of the Sun, and reclination of the plane being given, to find what time of the day or yeare the Sunne forſaketh the North reclining part, to ſhine upon the South inclining part thereof.

IN the former ſcheme, the circles E L W, E a W, and E H W, repreſent the three ſorts of North recliners; whereof that which reclineth 51 deg. 32′. lyeth in the plane of the Equinoctiall circle, of which I have ſpoken before. For the plane reclining 25 d. repreſented by the circle E L W during the Suns ſoutherne declination, it only ſhines upon the inclining ſide: but during his abode in the Northerne ſignes, ſome part of the day upon the reclining ſide, and ſome part upon the inclining, as doth plainly appeare in the ſcheme; for from the ſunne riſe in ♋, till it come to 25 d. where the tropique cutteth the plane, it ſhineth upon the reclining ſide, from 25 to O upon the inclining ſide, and from O to the Sun ſetting in ♋ upon the reclining ſide againe: which times are thus to be found. Draw a Meridian, or houre circle from P to M, in the Æquator, by O the interſection of the plane and tropique; the like may be drawne on the other ſide alſo; the angle M P a giveth the time deſired: which may be found by three ſeverall triangles: for in the quadrantall W a L, you have L a 26 d. 32′. and O M 23 d. 31′. and the quadrant a W 90 d. to find the ſide M W, whoſe complement is M a, the time deſired; *by the ſecond of the fourth of Pitiſcus*, or in leſſer triangle W M O, you have the an-

gle

gle at W, whose measure is L a, and the lesser side M O, to find the greater side M W, *by the second of the fourth case of right angled Sphericall Triangles:* or lastly, in the verticall triangle P O L, you have the right angle at L, and the base P O opposite thereto 66.d 29′, and the greater side P L 63 d. 28′, to find the lesser angle at P, *by the first of the 14 case of R.S. triangles.* For

			Logar.
As the sine of P L O	90 d.	0′.	10000.00
Is to the cotangent P O	66	29	9638.65
So is the tangent of P L	63	28	10301.63
To the cosine of O P L	29	22	19940.28

Which 29 d. 22′. resolved into time, giveth 1 houre 7′. $\frac{1}{3}$, both before and afternoone, when the Sun in Cancer forsaketh, and returneth againe to the reclining part of the plane.

In like manner, during the abode of the Sunne in Northerne signes, it only illuminateth the upper face of the plane, reclining 70 d. represented by the circle E H W, the rest of the yeere it shineth upon both (whose times are easily found by the declination) untill the Meridionall recesse of the Sunne from the Zenith be greater then the reclination of the plane, and then it shineth only upon the inclining part thereof. To find the time of the yeere for that, first draw the Ecliptique line W T B, then subtract Z a the reclination of the Equinoctiall 51 d. 32′. out of Z H, the reclination of the plane 70 d. there will rest a H 18 d. 28′. the declination of the paralell, when the Sunne forsaketh the reclining side, and onely shineth upon the inclining side of the plane; by the declination and amplitude draw this paralell K H (or seek the center thereof by the rules of the fourth Chapter) which shall crosse the Ecliptique W B at T, whose degree and minute, from either cardinall point I would know. In the quadrantall W B a I have the greatest declination given B a, and the particular declination of the plane, or paralell T I, equall to H a; to find the side W T, *by the first axiome of Pitiscus R. S. triangles:* or in the small triangle T I W, to find the same, *by the first of the eight case of R. S. triangles.* For

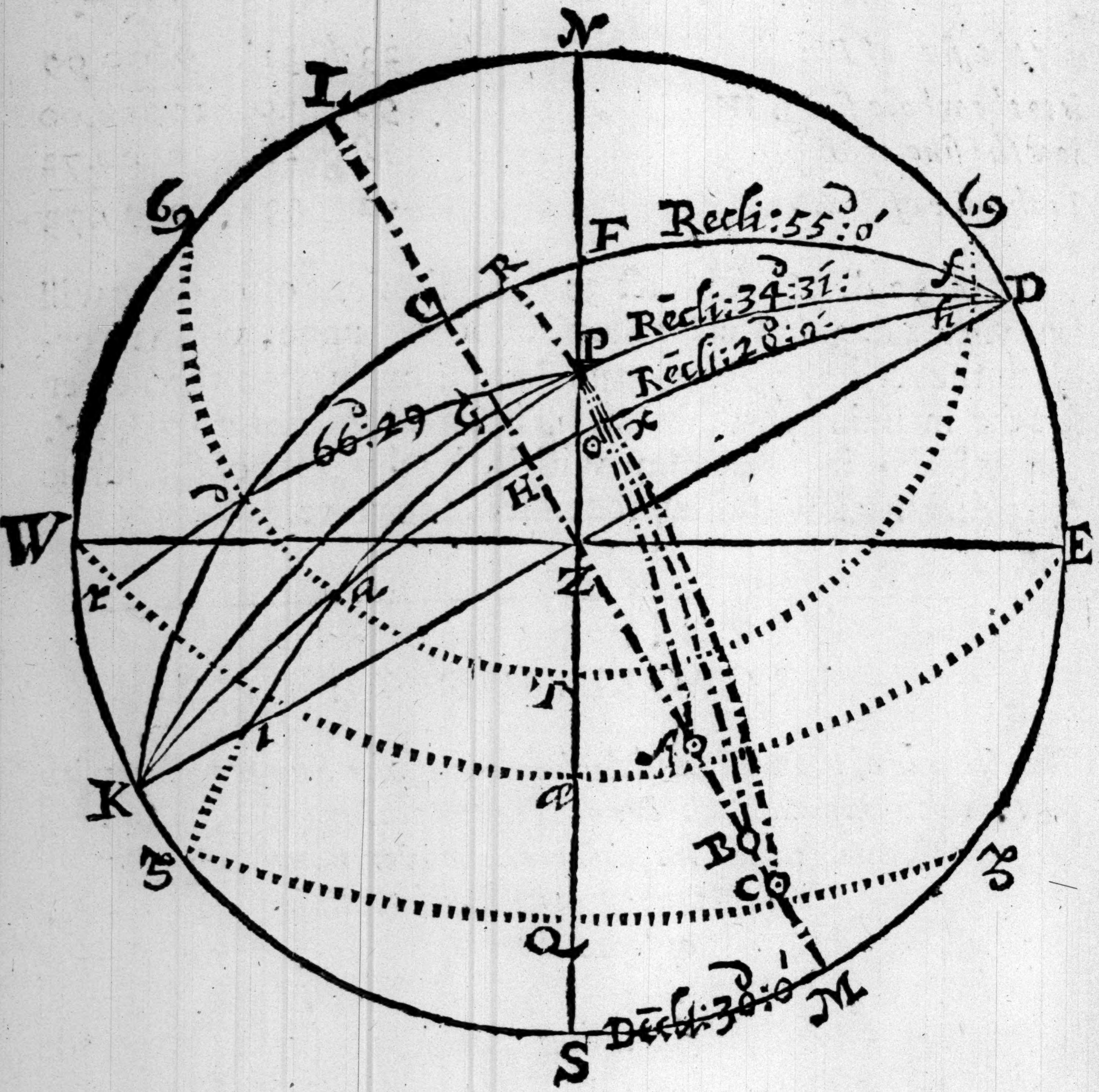
			Logar.
As the sine of B a	23 d.	31′.	9600.99
Is to the whole sine B W	90	0	10000.00
So is the sine of T ȝ	18	28	9500.72
To the sine of T W	52	33	9899.73

Out of 52 d. 33′. subtract 30 d. for the signe of ♎, there will remayne 22 d. 33′ of ♏ for the place of the Sunne, when it forsaketh the reclining plane, and shineth onely upon the nether face the inclining part thereof, till it ascend againe into 7 d. 27′. of ♒, which is in paralellisme with it, by this place of the Sunne every Almanack will shew the time of the yeere.

PROPOSITION VI.

The altitude of the pole, and declination of the Sun, together with the declining and reclining of the plane being given, to find what time the Sun forsaketh the North inclining side, to shine upon the South reclining opposite thereto.

IN declining reclining planes there are the same varieties, that are in the direct reclining; the first three cases are represented in this Scheme, wherein let K Z D be a South declining plane from E or W 30 d. as much as the poles thereof M, L, decline from S or N of the Meridian, and let the three reclining planes bee K H D 20 d. 0′. the example of the 15 Chapter, and K G D 34 d. 31′. the example of the 14 Chapter, and K F D, 55 d. 0′. the example of the 16 Chapter, in all which I would find the time that the Sunne forsaketh the one side of the plane, to shine upon the other; And first you may observe from the bare sight of the scheme, because the tropique of Cancer ♋ T ♋, crosses each of these planes in two places,



places, once at f and h, againe at a and d, that therefore the Sun in that tropique will both Morning and Evening shine upon the inclining parts of these planes, untill the amplitude thereof be 30 degrees equall to the declination of the planes, from which time following hee shineth upon the inclining part no more in the Morning. Now then draw P d r, and P a I two Meridians, or houre circles, from the pole P, crossing the planes K C D, and K H D, in the tropique of ♋ at d and a: the like should be done at f and h, but to auoid confusion of lines; In the right angled triangle P R D you have the base P d, the complement of the declination 66 d. 29'. and the side P R, the heighth of the pole or stile

ſtile above the plane, found by the 16 Chapter to be 19 d. 25′. and in the ſame place the angle R P N, betweene the two Meridians 17 d. 38′. (which two things I borrow as often as there is cauſe, to facilitate the worke, conſidering they muſt of neceſſity be found before the Diall can be made) by helpe whereof to find the angle d P R. *by the ſecond of the* 14. *caſe of R. S. Triangles.*

			Logar.
As the ſine of P R d	90 d.	0′.	10000.00
Is to the cotangent P d	66	29	9638.65
So is the tangent of P R	19	25	9547.14
To the coſine of d P R	81	11	19185.79

Vnto the angle d P R 81 d. 11′. adde the angle N P R, 17 d. 38′. the whole angle N P D is 98 d. 49′. 90 d. is 6 houres, therefore 8 d. 49′. reſolved into time, giveth 0 houre 35′. before ſix at night, when the Sunne in ♋ forſaketh the plane reclining to ſhine upon the inclining ſide thereof, or againe the angle d P R is equall to æ P r, 81 d. 11′. which reſolved into time, gives five houres, 25′. from noone. In like manner in the triangle P X a, right angled X, you have P a 66 d. 29′. as afore, and P X the length of the ſtile, 13 d. 49′. and X P O 28 d. 52′. the angle of the Meridians by the 15 Chapter, to find a P O the angle deſired, *by the ſecond of the* 14 *caſe of R. S. Triangles.* For

			Logar.
As the ſine of P X a	90 d.	0′.	10000.00
Is to the cotangent P a	66	29	6638.65
So is the tangent P X	13	49	9390.81
To the coſine of a P X	83	51	19029.46

Out of the angle a P X 83 d. 51′. ſubtract the angle X P O 28 degrees 52′. there remaynes the angle a P O 54 degrees 59′. which converted into time, giveth three houres 40′. afternoone, when the Sunne parteth from the plane reclining 20 degrees 0′. and ſhineth upon the inclining part oppoſite thereto.

to : For the times at f and h, when the Sunne neere his rising forsaketh the inclining sides of these planes, to shine upon the reclining sides thereof, you need resolve no Triangle, f P R being equall to d P R. Wherefore as you adde R P N, 17 d. 38'. to d P R, so must you subtract it from f P R, and there will remain f P N 63 d. 33'. which converted into time, gives 4 houres 14'. from midnight, that is neere a ¼ after 4 when the Sunne leaveth the inclining part of that plane; likewise h P X is equall to a P X, therefore adde X P o 28 d. 52'. unto h P X 83 degrees 51'. the whole angle h P O is 112 degrees 43'. whose complement to 180 d. gives N P h 67 d. 17'. either of which resolved into time, giveth the houre respectively, *viz.* 112 d. 43'. giveth 7 houres 31'. from noone, or 67 d. 17'. giveth 4 h. 29'. from midnight, when the Sun leaveth the inclining side, and shineth upon the opposite side reclining 20 d. 0'. Lastly, every plane reclining to the pole, as K P D doth, is coincident with some houre circle or part, and therefore the Sun in what paralell soever, passeth from one side of that plane to the other, at the same houre and minute; which you may find either by the triangle G P Z, *by the second of the fifteenth case*, or by the verticall to it N P D, *by the second of the sixteenth case of R. S. Triangles.* For

			Logar.
As the sine N P	51 *d.*	32'.	9893.74
Is to the sine of P N D	90	0	10000.00
So is the tangent of N D	60	0	10238.56
To the tangent of N P D	65	41	10344.82

Unto which G P Z *is also equall.*

Which 65 d. 41'. being converted into time, doth give 4 houres 23'. almost, reckoned from midnight, when the Sun passeth of the inclining to the reclining plane, and reckoned from noone, when he forsaketh the reclining, and shineth upon the inclining side againe. And thus it continueth till the Northerne amplitude of the Sun be equall to E D 30 d. the declination of the plane, from thence forth it shineth no more upon the inclining part in the morning, and when the Southerne amplitude of the Sun

Sun is equall to W K 30 d. the declination of the plane, then it forsaketh the inclining side at the evening also, and the rest of the yeere it onely enlighteneth the reclining side of the plane.

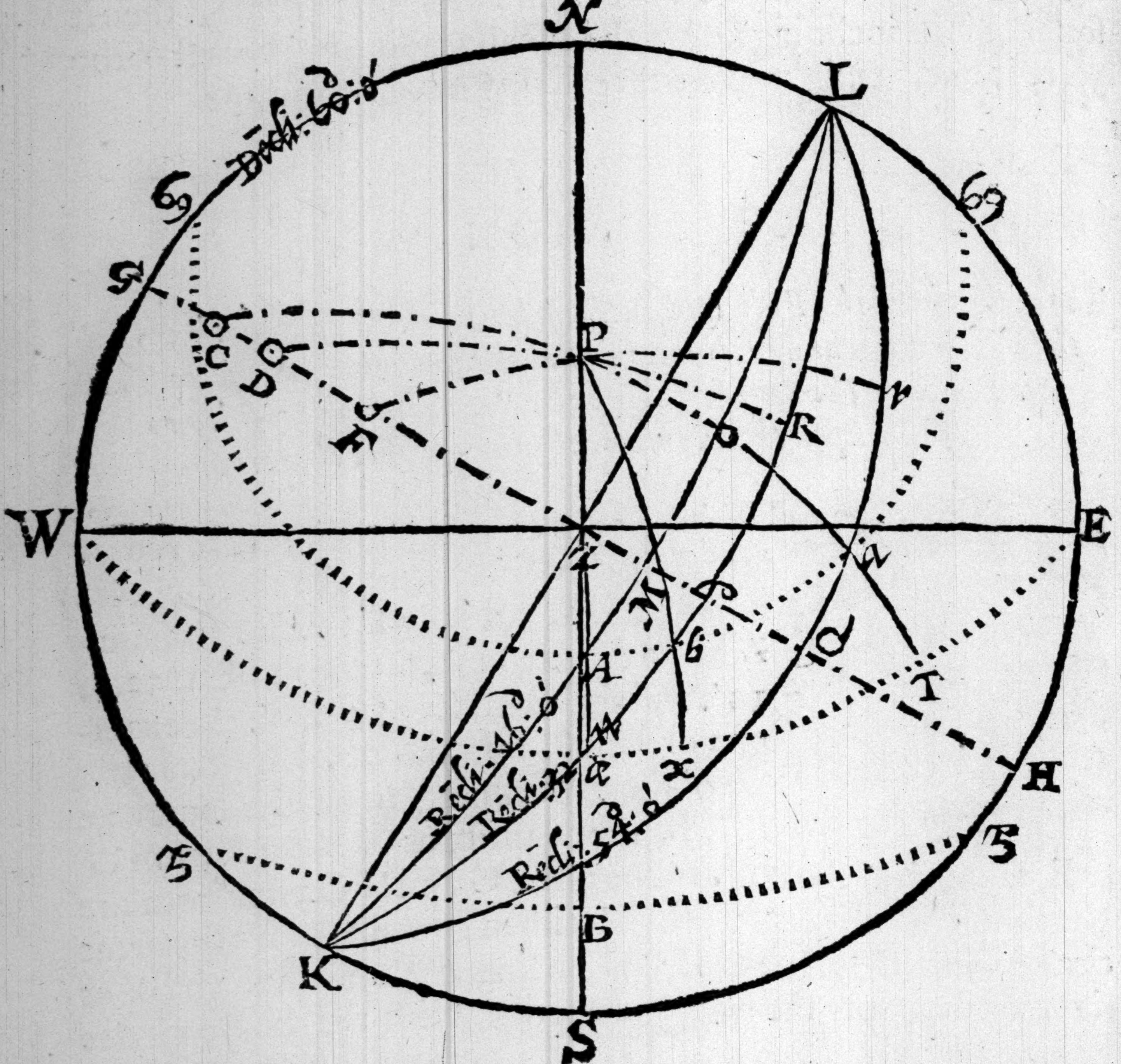
PROPOSITION VII.

The altitude of the Pole, and declination of the Sun, together with the declination and reclination of the plane being given, to find what time the Sun forsaketh the South inclining side, to shine upon the North reclining opposite thereto.

THe three cases of North recliners are represented in this Scheme by the three circles K M L, K d L, and K Q L, the first reclining Z M 16 d. 0'. from Z, the second Z d. 32. d. 11'. and the third Z Q 54 d. 0'. the examples of the 18. 19. and 20. Chapters: but all of them declining upon the same base K Z L, the quantity of W K 60 d. from W or E, as much as the poles of the plane G and H decline from the North and South parts of the Meridian N and S. Now the great circles F P r, D P R, and C P O, being drawne, which fall at right angles upon the planes, together with the houre circles P O T, P b x, and P A æ, falling at right angles upon the Equinoctiall', you have severall right angled triangles framed to determine the times required; First therefore for the plane reclining 54 d. 0'. the houre circle P O T cutteth the plane in ♋ at a, making the triangle P r a, whose angle at P I would know. P a is the complement of the declination 66 d. 29'. and P r the heighth of the stile above the plane 54 d. 43'. *(by the 20 Chapter)* wherefore *by the first of the fourteenth case of R. S. triangles:*

			Logar.
As the sine of P r a	90 *d.*	0'.	10000.00
Is to the cotangent P a	66	29	9638.65
So is the tangent P r	54	43	10150.21
To the cosine of R P a	52	3	19788.86

Vnto



Vnto the angle r P a 52 d. 3′. adde the angle betweene the Meridians (found by the twentieth Chapter to be 61 d. 47′. from the North) *viz.* N P r, or take r P a 52 d. 3′. out of the angle r P S 118. d. 13′. counted from the south, there remaynes 66 d. 10′. for the angle S P a, which converted into time, giveth 4 houres 24′. ½ before noone, when the sunne in ♋ forsaketh the inclining side of the plane, and shineth upon the reclining side thereof.

In the next case, the houre circle P b X crosseth the plane in ♋ at b, and maketh the triangle P R b, wherein as afore, I have the base P b 66 d. 29. and the side P R (found by the 18 Chapter) 42 d. 52′. the heighth of the stile above the plane, and in the same place,

place, the angle betweene the Meridians N P R 90 d. as it is in all declining reclining, which passe thorough the intersection of the Meridian and Equinoctiall, wherefore *by the second of the 14 case of R. S. triangles.*

As the sine of P R b	90 *d.*	0′.	10000.00
Is to the cotangent P b	66	29	9638.65
So is the tangent P R	42	52	9967.63
To the cosine of b P R	66	11	~~1~~9606.28

Out of the angle æ P R 90 0′. take the angle b P R 66 d. 11′. there will remayne 23 d. 49′. for the angle æ P b, which converted into time, giveth 1 houre 35′. before noone, when the sunne leaveth the inclining, and shineth upon the reclining side of the plane. Lastly, the Meridian or houre circle P A æ cutteth the reclining plane K M L in ♋ at A; wherefore in the triangle P O A, I have the right angle at O, and the base P A opposite therto 66 d. 29′. as afore, and the side P O, the heighth of the stile above the plane (found by the 19 Chapter) 30 d. 59′. and in the same place the angle æ P O betweene the two Meridians 76 d. 10′. by helpe whereof to give the small angle æ P A, *by the second of the 14. case of R. S. triangles.* For

			Logar.
As the sine of P O A	90 *d.*	0′.	10000.00
Is to the cotangent of P A	66	29	9638.65
So is the tangent of P O	30	59	9778.49
To the cosine of A P O	74	51	~~1~~9417.14

Out of the angle betweene the Meridians æ P O 76 d. 10′. take the angle A P O 74 d. 51′. there will remayne the small angle æ P A, 1 d. 19′. which converted into time, giveth 0. houre 5′. only before noone, when the sunne forsaketh the inclining, and shineth upon the reclining side of the plane: And these be all the varieties, that can happen upon any kind of plane; many other uses may be made of these propositions, though for the present

sent

ſent worke they ſerve but to leave the ſuperfluous houres out of every Diall.

PROPOSITION VIII.

The altitude of the Pole, and declination of the Sunne, together with the declination, or reclination, or declination and reclination of any plane being given; to find in what Country it would be a horizontall plane.

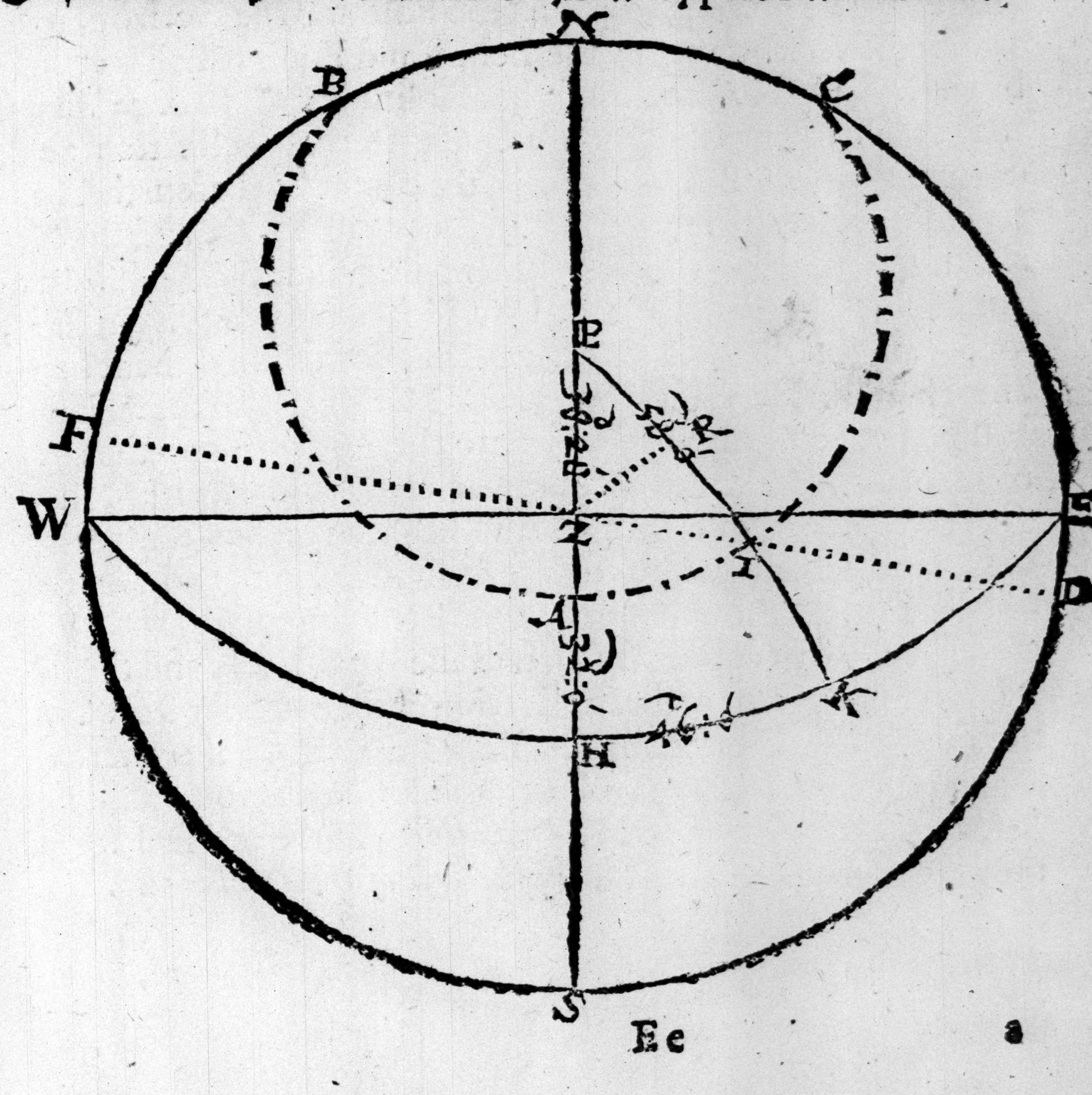
TO reſolve this queſtion, there is one generall rule, *viz.* the Diall being calculated to any declination, or reclination, or declination and reclination given, the angle betweene the two Meridians of the place and the plane is the longitude, and the heighth of the ſtile, or pole above the plane, is the latitude of that Countrey, where the plane propoſed would be horizontall: and the declination Eaſt or Weſt ſheweth the bearing of the place from us; if the Subſtile happen upon any houre line, then are the Dials of both places the ſame, reckoning the houre of 12 (and the reſt in order) from the Meridian of the place, in the one, and from the Meridian of the plane in the other; if otherwiſe you may eaſily put on the horizontall houre lines proper thereunto, by the direction of the 27 Chapter.

PRO-

PROPOSITION IX.

The longitude and latitude of any place being given, to make a plane in our latitude paralell thereto.

IN the Diagram adjoyning, let NESW, be the Horizon at *London*, Z the Zenith, and pole thereof, EHW the Equinoctiall of that latitude, whose distance from the Zenith is equall to the elevation of the Pole P above the Horizon; NPZS the Meridian of *London*, & EZW the prime vertical there; now suppose I would frame



a plane here, lying in the longitude and latitude of *Hierusalem*, or any other famous Citie within our *Hemisphere*, whereupon to make a Diall that shall shew the houres of that particular place.

Considering therefore that the difference of longitude betweene any two places, is an arch of the Æquator betweene the Meridians of the one and the other, subduct the longitude of *London* (which in the 180 page of Master *Wrights errours of Navigation*, is 22 d. 0′.) out of the longitude of *Hierusalem*, which in the same place is 68 d. 0′. the remainder 46 d. 0′. must be set upon the Equinoctiall from H to K Easterly: and from P the Pole at *London*, a great circle must be drawne to K, representing the Meridian of *Hierusalem*, 46 d. 0′. to the Southeast of our Meridian. Againe, considering that the latitude of every place is an arch of the Meridian betwixt the Pole and the Horizon, unto which the arch betweene the Zenith and Equinoctiall is equall; by the latitude H A 32 d. and the amplitude E C 58 d. 25′. found in the table of amplitudes answerable to the declination 32 d. draw the paralell B A C, (or seeke the center by the fourth Chapter) thorough I the intersection of the parall B A C, and the Meridian P I K, draw the streight line or azimuth Z I D, so have you an oblique triangle P Z I, by which to resolve this question, for the angle S Z D will give the declination of the plane, it being an arch of the Horizon betwixt our Meridian and the Azimuth passing by the Zenith of the place to the Horizon; and the complement of Z I, the distance betweene the two Zeniths, doth give the reclination of the plane, which is an arch of the said azimuth betwixt our Zenith and the reclining plane, and are thus to be found. In the oblique triangle P Z I you have the side P Z, the complement of the elevation of the P. 38 d. 28′. and the side P I the complement of the declination of the paralell 58 d. 0′. and the angle comprehended by them Z P I, 46 d. 0′. the difference of longitude betweene *London and Hierusalem*, to find the side Z I, *by the sixth case of O. S. Triangles.* Wherefore first let fall the perpendicular Z R. Then *by the case of O. S. triangles.*

As

			Logar.
As the sine of ZRP	90 *d.*	0'.	10000.00
Is to the tangent of ZP	38	28	9900.09
So is the cosine of RPZ	46	0	9841.77
To the tangent of PR	28	54	19741.86
Which taken out of the side PI	58	0	
There remaynes RI	29	6	

Then againe:

			Logar.
As the cosine of PR	28 *d.*	54'.	0057.76. *Ar. Compl.*
Is to the cosine of PZ	38	28	9893.74.
So is the cosine of RI	29	6	9941.40.
To the cosine of ZI	38	36	19892.90.

Whose complement 51 *d.* 24'. is the reclination sought for.

			Logar.
As the sine of ZI	38 *d.*	36'.	0204.89. *Arith. Compl.*
Is to the sine of ZPI	46	0.	9856.93.
So is the sine of PI	58	0.	9928.42.
To the sine of the angle PZI	77	54	19990.24.

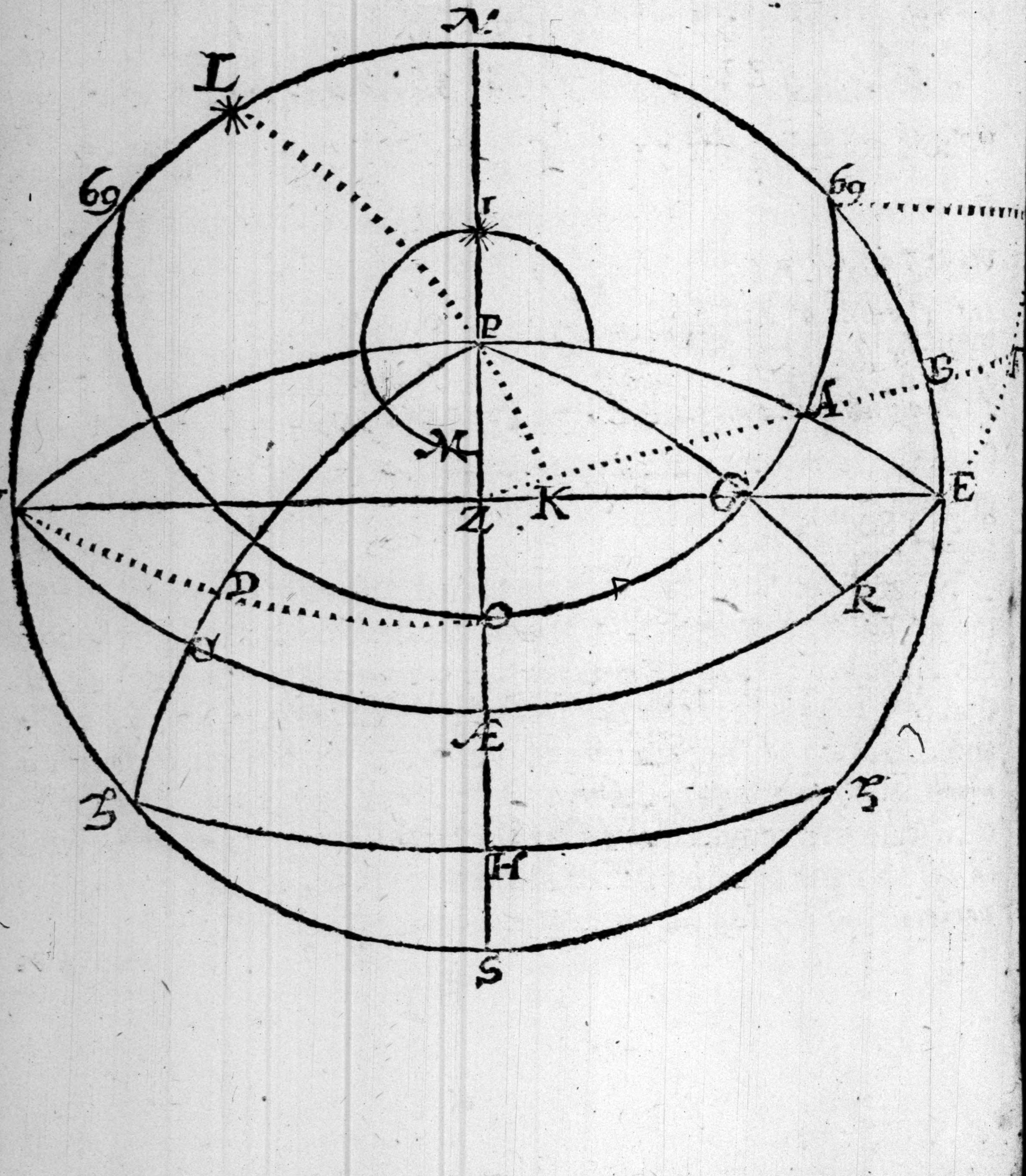
The true angle PZI is 102 d. 6'. and the complement thereof to 180 d. § ZD is 77 d. 54'. the angle of declination which we seeke for; but because there is no sine greater then 90 d. the complement of the obtuse angle to 180 d. is produced by the worke.

To conclude then, the plane which in our latitude of *London*, will lie parall to the longitude, and latitude of *Hierusalem*, must decline from our Meridian Eastwards 77 d. 54'. and recline from our Zenith Northwards 51 d. 24. which was the thing desired.

CHAP. XXXVI.

Divers other Propositions of the Spheare in ordinary use to be performed by right angled sphericall triangles only.

IN the Scheme adjoyning, let N E S W be the Horizon, N P Æ S the Meridian, E Z W the prime verticall, ♋ G ♋ the tropique of *Cancer*, E Æ W the Æquator, ♑ H ♑ the tropique of Capricorne, P G R a Meridian or houre circle, crossing the prime verticall in the point G, the Sun being



in the tropique of *Cancer*, E P W the houre circle of 6 of clock, Z A B the azimuth of the Sunne croſſing that houre circle in the point A, the Sunne being in the tropique of Cancer, W D G a quarter of the Ecliptique, and P D ♑ a Meridian drawn from the Pole to the place of the Sun ſet upon the Horizon in ♑, croſſing the Ecliptique in D, and the Equinoctiall at right angles in C.

Let the triangle W C D of the Scheme repreſent the triangle ♈ R ♉ of *the* 1. *Caſe of R. S. Triangles*, W D is part of the Ecliptique, W C part of the Æquator, and D C part of the circle of declination, falling at right angles upon the Equinoctiall in C.

1 The greateſt declination of the Sunne which is the angle at W, and his diſtance from the next Equinoctiall point W D being given, to find D C the particular declination of any degree of the Ecliptique: worke *by the firſt varietie of the firſt caſe of R. S. triangles.*

2 By the ſame *data* to find W C the right aſcention, worke *by the ſecond of the ſecond caſe of R. S. triangles.*

3 By the right aſcention W C, and declination D C, to find W D the diſtance of the Sun from the next Equinoctiall point, worke *by the ninth caſe of R. S. triangles.*

4 By the ſame *data* to find the angle D, which the Meridian maketh with the Ecliptique, worke *by the ſecond of the* 16. *caſe of R. S. Tringles.*

5 By the right aſcention W C, and the diſtance of the Sunne from the next Equinoctiall point W D, to find the angle W, the greateſt declination, worke *by the firſt varietie of the fourteenth caſe of R. S. triangles.*

Now theſe five parts may be varied 30 ſeverall wayes, as by the 16 caſes appeareth, *viz* the particular declination five wayes more, *by the firſt varieties of the firſt ſix caſes*, and the right aſcention five wayes more *by the ſecond varieties of the ſame ſix caſes*, and the place of the Sun five wayes more, *by the ſeventh, eighth, ninth, and tenth caſes*, and the angle of the Meridian, and the Ecliptique five wayes more, *by the ſecond varieties of the ſixe laſt caſes*, and the greateſt declination five wayes more, *by the firſt varieties, of the laſt ſix caſes of R. S. triangles.*

Againe let the triangle W C ♑ of the scheme represent the triangle ♈ R ♉ of *the first case of R.S. triangles.* C W ♑ may be the East or West point, where the Æquator and Horizon intersect each other, W ♑ part of the Horizon from that point to the place of Suns rise or Suns set, ♑ C part of the Meridian passing by the place of the Sunne, and falling upon the Æquator at right angles in C, and this triangle is properly framed under the Horizon, as is E T ♋, by continuing the Æquator to the Meridian (like the example of the sixt Chapter) but would be equall to this being opposite thereto, which therefore I retaine.

6 The complement of the heighth of the Pole, which is the angle at W, and the declination of the Sun, which is C ♑, being given to find the difference ascentionall W C, equall to E T, worke *by the second of the fourth case of R. S. Triangles.* This difference ascentionall added to 90 d. in North signes, and subducted in South signes, giveth the ½ diurnall arch in degrees and minutes, which may be converted into time for the length of day and night time of Suns rise and Suns set.

7 By the same *data* to find the amplitude W ♑, equall to E ♋, worke *by the first of the eighth case of R.S. triangles.*

8 By the amplitude W ♑, and the difference ascentionall W C, to find the declination C ♑, worke *by the first of the third case of R.S. triangles.*

9 By the amplitude of W ♑, and the declination C ♑, to find the angle W, which is the complement of the heighth of the Pole, worke *by the first of the* 15. *case of R.S. triangles.*

10 By the declination C ♑, and complement of the poles heighth the angle W, to find the angle at ♑, which the circle of declination makes with the Horizon, worke *by the second of the* 11 *case of R.S. triangles.*

Now these five parts of this triangle may be also varied 30 severall wayes, by the same 16 cases as the former were, *viz.* the difference ascentionall may be found five wayes more, by the second varieties of the first six cases, and the amplitude five wayes more, by the seventh, eighth, ninth, and ten cases, and the declination 5 wayes more, *by the first varieties, of the first six cases,*

and

and the complement of the Poles heighth five wayes more, *by the first varieties of the last six cases*, and the angle of the Meridian and Horizon five wayes more, *by the second varieties of the last 6 cases of R.S. triangles.*

Again let the triangle G R E of the schem represent the triangle ♈ R ♉ of the first case of R.S. triangles, G E R may be the East or West point, where the Æquator, Horizon and first and verticall crosse each other, G E part of the prime verticall, and G R part of the Meridian, or houre circle, passing by the place of the Sun in ♋ upon the prime verticall at G, and falling at right angles upon the Æquator in R.

11 The elevation of the pole, which is the angle at E, and the declination of the Sun G R being given, to find G E the heighth of the Sun upon the prime verticall, worke *by the second of the eighth case of R.S. triangles.*

12 By the same *data* to find R E the houre of the Suns comming, to the first verticall, worke *by the first of the fourth case of R.S. triangles.*

13 By the angle at E the heighth of the Pole, and the side G E, the heighth of the Sun upon the prime verticall, to find the declination G R. worke *by the second of the eleventh case of R.S triangles.*

14 By the houre of the Sun R E, and the declination G R, to find the angle at E, which is the heighth of the Pole, worke *by the second of the 16 case of R.S. triangles.*

15 By the heighth of the Sun upon the prime verticall G E, and the declination G R, to find the angle at G, which the Meridian makes with the prime verticall, worke *by the first of the fourteenth case of R.S. Triangles.*

Now these five parts of this triangle may be varied thirty severall wayes, as the former were, by the aforesaid 16 cases, *viz.* the heighth of the Sunne upon the first verticall five wayes more *by the seventh, eighth, ninth, and tenth cases*, the houre of the Sun comming to the prime verticall five wayes more *by the first varieties of the first six cases*, the declination five wayes more *by the second varieties of the same six cases*, the heighth of the Pole five wayes more *by the second varieties of the last six cases*, and the

angle of the Meridian, and the first verticall five wayes more *by the first varieties of the same six cases of R.S. triangles.*

Againe, let the triangle A B E of the Scheme represent the triangle ♈ R ♉, of the first case of *R.S.* triangles, and let the angle at E be the East point as afore, A E part of the houre circle of six, and A B part of the azimuth crossing the place of the Sunne in ♋ at A upon the said houre circle.

16 The angle E the heighth of the pole, and A E the declination of the Sun being given, to find A B the heighth of the Sun upon the houre circle of 6, worke *by the second of the first case of R.S. triangles.*

17 By the same *data,* to find E B the azimuth of the Sunne at the same time, worke *by the first of the second case of R. S. triangles.*

18 By the heighth of the Sun A B, and the azimuth E B, to find the declination A E: worke *by the ninth case of R.S. triangles.*

19 By the azimuth E B, and the declination E A, to find the angle E, the heighth of the Pole: worke *by the second of the* 14 *case of R. S. triangles.*

20 By the angle E, the heighth of the pole, & A B the heighth of the Sunne upon the houre circle of 6, to find the angle of the Suns position at A, worke *by the first of the* 11 *case of R.S. triangles.*

And these five parts of this triangle may be also varied 30 severall wayes by the 16 Cases aforesaid, as all other right angled triangles may be, so that the heighth of the Sunne upon the houre circle of 6 may be found five wayes more *by the second varieties of the first six cases,* the azimuth of the Sun five wayes *by the first varieties of the same six cases,* the declination five wayes more *by the seventh, eight, ninth, and tenth cases,* the heighth of the Pole five wayes more *by the second varieties of the last six cases,* and the Suns position five wayes more, *by the first varities of the same six cases of R. S. triangles.*

21 Now if you suppose Z A B to be a decliningplane, and crosse it at right angles with the Meridian P K, you have the right angle triangle Z K P, wherein the particulars desired of all declining

planes

planes are represented, for P K is the elevation of the pole above the plane, Z K the distance of the substile from the Meridian, Z P K the angle betweene the two Meridians, P Z K the complement of the declination, and P Z the complement of the heighth of the Pole of the place: But these things being at large discussed in the tenth Chapter, it were needlesse to repeat them againe, only I thought fit to remember, that these five parts of this triangle may by the 16 Cases aforesaid be varied 30 severall wayes, so that one may abundantly satisfie himselfe in all these conclusions by divers operations, and therfore the more confidently rest upon his owne worke, producing the same truth from severall *data*.

22 Againe by the same triangle P K Z, you may calculate the houre arches of the former table, for if you suppose P K to be an houre circle, and Z B the azimuth crossing it at right angles in K, the side P K, being found by the Canon annexed to the table, shall give the arch of the table desired, and by the 16 cases you may find all the other parts in that triangle if you thinke good.

23 Likewise having found by the sixt proposition the difference ascentionall E T, or W C, if you subtract it out of the right ascention of any degree of the Ecliptique in Northerne signes, you have the oblique ascention thereof, and adde it thereto, you have the oblique descention thereof, contrary, if you adde it to the right ascention of any Southerne signe, you have the oblique ascention thereof, and by subtracting it, the oblique descention of the same place.

24 The heighth of the Pole, and greatest declination being given, to find what arch of the Zodiaque never riseth or setteth in that latitude, and consequently the longest day or night of that paralell, and contrary.

When the elevation of the Pole is lesse then 66 d. 29′. the complement of the greatest declination, all the parts of the Ecliptique doe both rise and set; when just so much ♋ and ♑ cut the Horizon, when it is more part of the Ecliptique is alwayes above, and part alwayes under the Horizon: suppose 72 be the latitude neere the *North Cape* of *Finmarke* going to *Russia*, the complement thereof is 18 degrees the declination of that paralell, that

never

neuer ſetteth in that latitude, the greateſt declination being given, this particular declination may be found *by the 1 of the 8 caſe of R.S. triangles.* to belong to 20 d. 45′. of ♉, or ♏ but 9 d. 15′. of ♌ and ♒ are in paralelliſme with them, therefore the arch of the Ecliptique from 20 d. 45′ of ♉ to 9 degrees 15′. of ♌ is alwayes above that Horizon, and continuall day from about the firſt of *May*, to the 23 of *Iuly* following, the contrary part of the yeare is continuall night, and of the Ecliptique never riſeth.

25 The arch of any degree of the Ecliptique, from the next Equinoctiall point, and the right aſcention thereof being given together, to find what each of them are ſeverally, ſuppoſe that aggregate be 57 degrees 54′. for ſolution of this queſtion, the greateſt difference betweene the arch of the Ecliptique and his right aſcention muſt be knowne; which you may either calculate, or find by any Table of right aſcentions to be about the middle of ♉ or ♏ 2 degrees 29′. then *by the firſt of the firſt caſe of R.S. triangles*, you ſhall find the fourth proportionall to be 2. degrees 6′. which ſubtracted from 57 degrees 54′. leaveth the double of the right aſcention, and added to the right aſcention 27 d. 54′. giveth the arch of the Ecliptique from ♈ 30 d.

26 The Meridionall altitude, and declination of any knowne ſtarre that never ſetteth being given, to find the heighth of the Pole; let the Meridionall altitude of ſuch a ſtarre be N I, or N M, and the declination thereof Æ M, therefore the complement M P, or P I, to the leaſt heighth N I adde the complement of the declination I P, or from the greateſt heighth N M ſubtract the complement P M, ſo have you P N, the heigth of the pole, to be corrected by refractions if there be cauſe.

27 The right aſcention and declination of two knowne ſtars being given, whereof the one in the Horizon, the other in the Meridian, to find the heighth of the Pole without inſtrument. In the triangle P N L right angled at N, the difference of the right aſcentions of the ſtars in I and L is the angle N P L, and the complement of the declination of the ſtarre at L in the Horizon is the ſide P L: wherefore *by the ſecond of the ſecond caſe*

of

of *R. S. triangles*, you may find the side P N, the heighth of the Pole desired.

Infinite are the propositions of the like kind, that might be added; which I leave the ingenious Reader in imitation of these to find out of himselfe; least varietie of conclusions, which have no bounds, should swell this Booke into a boundlesse Volume.

A Table of Amplitudes, for the Suns rising or setting in each degree of the Ecliptique.

♈	♎	Decli:		Amplit.		♉ ♏ Decli:		Amplit.		♊ ♐ Decli:		Amplit.	
Degrees		d	'	d	'	d	'	d	'	d	'	d	'
0	30	0	0	0	0	11	31	18	44	20	13	33	45
1	29	0	24	0	38	11	52	19	18	20	26	34	8
2	28	0	48	1	17	12	13	19	53	20	38	34	30
3	27	1	12	1	56	12	33	20	27	20	50	34	52
4	26	1	36	2	34	12	54	21	2	21	1	35	12
5	25	2	0	3	13	13	14	21	36	21	12	35	33
6	24	2	23	3	50	13	34	22	9	21	23	35	53
7	23	2	47	4	29	13	54	22	43	21	33	36	12
8	22	3	11	5	7	14	14	23	17	21	43	36	30
9	21	3	35	5	46	14	33	23	49	21	53	36	49
10	20	3	58	6	23	14	52	24	22	22	2	37	6
11	19	4	22	7	2	15	11	24	54	22	10	37	21
12	18	4	46	7	40	15	29	25	25	22	19	37	36
13	17	5	9	8	18	15	48	25	57	22	26	37	51
14	16	5	32	8	55	16	6	26	29	22	34	38	6
15	15	5	56	9	34	16	24	26	59	22	41	38	19
16	14	6	19	10	11	16	41	27	29	22	47	38	30
17	13	6	42	10	49	16	51	27	59	22	53	38	41
18	12	7	5	11	26	17	15	28	28	22	59	38	53
19	11	7	28	12	3	17	32	28	58	23	4	39	3
20	10	7	51	12	41	17	48	29	26	23	9	39	12
21	9	8	13	13	17	18	4	29	54	23	13	39	20
22	8	8	36	13	55	18	20	30	22	23	17	39	27
23	7	8	58	14	31	18	39	30	49	23	20	39	33
24	6	9	21	15	8	18	50	31	16	23	23	39	39
25	5	9	43	15	45	19	5	31	42	23	26	39	44
26	4	10	5	16	21	19	19	32	8	23	28	39	48
27	3	10	26	16	56	19	33	32	33	23	29	39	51
28	2	10	48	17	32	19	47	32	58	23	30	39	53
29	1	11	9	18	7	20	0	33	21	23	31	39	54
30	0	11	31	18	44	20	13	33	45	23	31	39	54

A Table for the Paralels proper to the latitude of 51 d. 32'.

Declina: d	Declina: '	Amplit. d	Amplit. '	Declina: d	Declina: '	Amplit. d	Amplit. '
23	45	40	21	31	15	56	30
24	0	40	50	31	30	57	8
24	15	41	19	31	45	57	46
24	30	41	49	32	0	58	25
24	45	42	18	32	15	59	5
25	0	42	48	32	30	59	44
25	15	43	18	32	45	60	25
25	30	43	48	33	0	61	7
25	45	44	18	33	15	61	49
26	0	44	48	33	30	62	32
26	15	45	19	33	45	63	16
26	30	45	50	34	0	64	1
26	45	46	21	34	15	64	47
27	0	46	52	34	30	65	35
27	15	47	24	34	45	66	24
27	30	47	56	35	0	67	14
27	45	48	28	35	15	68	6
28	0	49	0	35	30	68	59
28	15	49	33	35	45	69	55
28	30	50	6	36	0	70	54
28	45	50	39	36	15	71	55
29	0	51	12	36	30	72	59
29	15	51	46	36	45	74	8
29	30	52	20	37	0	75	21
29	45	52	55	37	15	76	40
30	0	53	30	37	30	78	8
30	15	54	5	37	45	79	48
30	30	54	41	38	0	81	46
30	45	55	17	38	15	84	25
31	0	55	54	38	28	90	0

A Table originally calculated, for every fift day of the yeare, the Meridian of London, *by our Countriman, and Mathemati-*

		The Sunnes place, 1623.			Decli-nation.		Com-plemēt		Differ: ascenti:		½ Diurnall arches.	
		d ♑	'		d	'	d	'	d	'	d	'
Ianuary.	5	25	12.	42	21	10	68	50	29	10	60	50
	10	♒ 0	18.	27	20	9	69	51	27	30	62	30
	15	5	23.	50	18	59	71	1	25	39	64	21
	20	10	28.	42	17	40	72	20	23	38	66	22
	25	15	33.	5	16	14	73	46	21	30	68	30
	30	20	36.	49	14	40	75	20	19	14	70	46
Februa:	5	26	40	19	12	40	77	20	16	26	73	34
	10	♓ 1	42	30	10	54	79	6	14	2	75	58
	15	6	43	54	9	4	80	56	11	35	78	25
	20	11	44	30	7	11	82	49	9	8	80	52
	25	16	44	14	5	15	84	45	6	38	83	22
	28	19	43	40	4	5	85	55	5	9	84	51
March.	5	24	41	56	2	7	87	53	2	39	87	21
	10	29	39	19	0	8	89	52	0	10	89	50
	15	♈ 4	35	51	1	50	88	10	2	19	92	19
	20	9	31	23	3	47	86	13	4	46	94	46
	25	14	26	4	5	43	84	17	7	14	97	14
	30	19	19	51	7	36	82	24	9	40	99	40
Aprill.	5	25	11	13	9	47	80	13	12	32	102	32
	10	29	57	6	11	30	78	30	14	50	104	50
	15	♉ 4	54	11	13	11	76	49	17	9	107	9
	20	9	44	28	14	47	75	13	19	24	109	24
	25	14	34	3	16	16	73	44	21	33	111	33
	30	19	22	57	17	38	72	22	23	35	113	35

1623. *according the place of the Sunne, corrected and rectified for cian of worthy memory Master* Edward Wright.

		Sunrise		Sunset.		Length of day.		Length of night.		Breake of day.		Twilight	
		H.	'	H.	'	H.	'	H.	'	H.	'	H.	'
Ianuary.	5	7	57	4	3	8	6	15	54	5	50	6	10
	10	7	50	4	10	8	.20	15	40	5	45	6	15
	15	7	43	4	17	8	34	15	26	5	39	6	21
	20	7	34	4	26	8	52	15	8	5	32	6	28
	25	7	26	4	34	9	8	14	52	5	25	6	35
	30	7	17	4	43	9	26	14	34	5	17	6	43
Februa:	5	7	6	4	54	9	48	14	12	5	8	6	52
	10	6	56	5	4	10	8	13	52	4	59	7	1
	15	6	46	5	14	10	28	13	32	4	50	7	10
	20	6	36	5	24	10	48	13	12	4	40	7	20
	25	6	27	5	33	11	8	12	52	4	30	7	30
	28	6	21	5	39	11	18	12	42	4	21	7	39
March.	5	6	11	5	49	11	38	12	22	4	12	7	48
	10	6	1	5	59	11	58	12	2	4	2	7	58
	15	5	51	6	9	12	18	11	42	3	50	8	10
	20	5	41	6	19	12	38	11	22	3	38	8	22
	25	5	31	6	29	12	58	11	2	3	25	8	35
	30	5	21	6	39	13	18	10	42	3	12	8	48
Aprill.	5	5	10	6	50	13	40	10	20	2	57	9	3
	10	5	1	6	59	13	58	10	2	2	41	9	19
	15	4	51	7	9	14	18	9	42	2	25	9	35
	20	4	42	7	18	14	36	9	24	2	8	9	52
	25	4	34	7	26	14	52	9	8	1	51	10	9
	30	4	26	7	34	15	8	9	52	1	32	10	28

		The Sunnes place, 1623.			Decli-nation.		Com-plement		Differ: ascenti:		$\frac{1}{2}$ Diurnall arches.	
		d ♉		'	d	'	d	'	d	'	d	'
May.	5	24	11	13	18	53	71	7	25	30	115	30
	10	28	58	52	20	0	70	0	27	16	117	16
	15	♊ 0	53	49	20	25	69	35	27	53	117	53
	20	3	46	1	20	59	69	1	28	52	118	52
	25	8	31	44	21	48	68	12	30	14	120	14
	30	13	19	3	22	29	67	31	31	24	121	24
		18	5	1	22	59	67	1	32	16	122	16
June.	5	23	47.	51	23	23	66	37	32	58	122	58
	10	28	33.	20	23	31	66	29	33	13	123	13
	15	♋ 3	18.	42	23	29	66	31	33	9	123	9
	20	8	4.	2	23	17	66	43	32	48	122	48
	25	12	49.	23	22	54	67	6	32	7	122	7
	30	17	34.	52	22	22	67	38	31	12	121	12
		22	20	30	21	40	68	20	30	0	120	0
Iuly.	5	27	6	23	20	49	69	11	28	35	118	35
	10	29	0	49	20	26	69	34	27	58	117	58
	15	♌ 1	52	34	19	49	70	11	26	58	116	58
	20	6	39	10	18	41	71	19	25	11	115	11
	25	11	26	8	17	25	72	35	23	15	113	15
	30	16	13	41	16	2	73	58	21	12	111	12
August.	5	21	59	27	14	14	75	46	18	37	108	37
	10	26	48	18	12	37	77	23	16	22	106	22
	15	♍ 1	37	52	10	56	79	4	14	4	104	4
	20	6	28	8	9	10	80	50	11	43	101	43
	25	11	19	10	7	21	82	39	9	21	99	21
	30	16	11	00	5	28	84	32	6	55	96	55

The two last leaves are placed before page 1.